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THE UNIVERSITY OF ALBERTA

PROBLEMS ASSOCIATED WITH PROVISION OF INDUSTRIAL SPARE PARTS IN TANZANIA

BY

© EZEL Y.L. MKWIZU

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

IN

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DEPARTMENT OF MECHANICAL ENGINEERING

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DATE: 30/12/91

DEDICATED WITH LOVE

TO MY PARENTS

YONAZI

SIFAEL

AND TO MY WIFE

MARY

ABSTRACT

Shortages of industrial spare parts are a serious problem for many Tanzanian industries. There is a lack of raw materials, manufacturing technologies, skilled manpower, machine tools and equipment for production of spare parts locally. Maintenance practices are inadequately carried out; there is a lack of proper maintenance records, improvised maintenance service and repair and inadequate data for evaluation and costing. Many industries depend on imported spare parts but the shortage of foreign exchange hampers their importation. An analysis of the spare parts problems in Tanzanian industries has revealed that the local resources have not yet been fully utilized.

The practice of manufacturing spare parts in the country, initiated by the President of the Republic of Tanzania in 1988, faces a number of problems. These problems are raw materials supply shortages, lack of special machines to handle serial production, stiff competition from cheap, high quality imported parts, poor collection of receivables and varied technical problems.

This study analyses the survey data collected from a number of Tanzanian industries and suggests possible solutions to the problems.

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1.0 INTRODUCTION

1.1 Purpose:

This study analyzes the causes of industrial spare parts problems in Tanzania and presents some recommendations considered essential to the solution of the spare parts problem.

Tanzanian industries face a spare parts problem which severely constrains the maintenance and repair of production machinery. Many industries are operating at low capacity utilization. In 1988, most industries operated at 20 to 40 percent capacity utilization [15,62]. The term "industries" in this context is restricted to those with capital investment in machinery and equipment such as the manufacturing and processing industries. The under-utilization of capital makes production costs very high and adversely affects profits. The spare parts problem is considered to be a significant contributor to this capacity under-utilization problem.

The study concentrates in particular on production under-capacity which emerged in the post Arusha Declaration (a ruling party announcement, in 1967, declaring Tanzania a socialist state) period and continues to the present. As an introduction to the analysis, some data relating to the

period from independence (1961) to the Arusha Declaration is included.

1.2 Background

Tanzania became independent in 1961 with a poorly developed industrial infrastructure compared to Kenya and Uganda at that time. The contribution of the manufacturing industry to Tanzania's Gross Domestic Product (GDP) was only 3.6 percent. Some characteristics of the industrial structure inherited from the colonial period are described in the second chapter of this study.

Crucial events in the period preceding the 1980's included the Arusha Declaration of 1967. It marked the shift from capitalism towards socialism and a self-reliant mode of production. Many industries were nationalized in order to check the emergence of economic inequality among the Tanzanian population. Through nationalization and new investment by the public sector, there was a shift in the industrial structure towards publicly-owned enterprises for the provision of goods and services to meet the needs of the population. These companies are called "Parastatals" (the Government owns all or majority shares). These measures were carried through with some success in terms of the proportion of the economy that came under the public sector. In some isolated cases foreign owners withdrew from private business

because of fear of nationalization or withdrew their management support from nationalized industries.

The period between the Arusha Declaration and the end of the first half of the 1970's was characterized by rapid growth of parastatals. Initially, many companies were operating well above average capacity utilization. However, the early euphoria generated by the parastatal prosperity started to diminish after 1970. The problem was lower productivity in parastatals than in the private sector. This productivity decline was triggered by a number of reasons including poor management (because social objectives were given higher priority than productivity and efficiency) and over-employment (because providing employment was an important social goal) [83].

Ten years after the Arusha Declaration (1977), many parastatals were operating well below capacity and perceived problems were: maintenance inadequacies, poor management, spare parts shortages, raw materials shortages, skilled manpower shortages, energy shortages and foreign exchange constraints.

Machinery availability is a major problem for Tanzanian industry. Machines are often not available because they have broken down and are not repaired. A major reason why

they are not repaired is because spare parts are not available. The problems related to provision of industrial spare parts are deterring smooth production in Tanzania's industries and are an obstacle to economic growth in Tanzania. Also, the lack of adequate stocks of spare parts for maintenance results in machines being poorly maintained, which leaves the economic viability of all industrial activities highly vulnerable.

Many of the problems in maintaining adequate inventories of spare parts relate to lack of foreign exchange and long lead times for ordering spare parts. The quantities ordered are based on the available foreign exchange, which is normally obtained from the National Bank of Commerce (NBC).

Most spare parts stores (maintenance stores) are not well-organized and planned: spare parts are not easily found, transaction recording systems (records of withdrawals and deliveries) are not appropriate. There are no proper forecasts for spare parts requirements and frequently stock-outs, overstocking, obsolescence and stock deterioration are encountered.

Raw materials required for manufacturing of spare parts, such as alloy steels, carbon steels and copper alloys are frequently not available in the local market. These

materials must be imported and the country is chronically short of foreign exchange so spare parts buyers are competing with many other potentially frustrated importers.

Poor management of operations is a problem in most of Tanzania's industries. This is believed to be caused partly by untrained and inexperienced managers. Inadequate training also extends to technical manpower who frequently have little or no academic or formal training skills in their relevant fields. The Government provides technical education and vocational training, and individuals receive their education locally or abroad at public expense. Unfortunately, there is not capacity in the educational system to train workers in the quantities and with the skills required by industry.

Unavailability of spare parts is aggravated by the limited capacity of local manufacturing. Foundry shops are equipped with old equipment and frequently lack the technology to manufacture the needed variety of spare parts. Engineering workshops, and their machine tools and equipment, are old and poorly maintained. A lack of modern machine tools and equipment hampers the local manufacture of most industrial spare parts. Further, the spare parts manufactured locally are often poor quality and as a result companies rely on imported parts.

1.3 Methodology and Scope:

This study is directed at the problems of spare parts availability. It therefore includes inventory management practices, spare parts reconditioning techniques, manufacturing technologies and equipment. It is concerned with the technical and operational aspects of the spare parts problem and not with ideology or the governments industrial strategy. However, since operational aspects are influenced by industrial structure, incentives, and economic environment, some description of the development history is included.

Chapter 2 of the study examines the events in Tanzanian industrialization from independence to the 1980's and discusses the emergence of the spare parts problem. The problem itself is mentioned as one cause of low capacity utilization. A detailed survey of present Tanzanian practices and capabilities was conducted. A summary of the survey results is included in Chapter 3. Chapter 4 is an analysis of the survey results. Chapter 5 examines the spare parts problem in detail. Using information from the survey, available statistics and literature, and the author's experiences in Tanzania's industries are used to examine critically the causes of the spare parts supply shortages. A case study of the STAMCO machine shop, a Canadian spare parts manufacturer was conducted in order to

contrast it with Tanzania's situation (in Chapter 6). The suitability and applicability of these practices to Tanzania's workshops are critically examined. Chapter 7 concludes the findings from this study and recommends short and long-term solutions for implementation by the Government and industries.

The study is restricted to mainland Tanzania (excluding Zanzibar). This is because the vast majority of industries are located on the mainland, plus most industrial studies during the period covered were restricted to the mainland portion of the United Republic of Tanzania. Most of the data in the study will therefore refer to mainland Tanzania.

2.0 Industrial Growth in Tanzania From 1961 to the 1980's:

The following is a review of some important aspects of economic development in Tanzania from independence (1961) to the 1980's, and an examination of achievements and failures in the process of industrialization.

The information is intended to describe the context in which I will explore the possible causes of problems such as lack of spare parts, lack of raw materials, low productivity, low capacity utilization, lack of foreign exchange and poor management of operations. These are problems which are characteristic of most of Tanzania's industries.

2.1 1961 - On the eve of independence:

In 1961, the level of industrial development was very low and the industrial structure was quite rudimentary. There were only 380 manufacturing establishments employing 10 or more people [72], which together accounted for only 3.6 percent of the Tanganyikan GDP. The predominant sector of the economy was agriculture, which accounted for 59 percent of the GDP [79]. The two sectors of some significance, apart from agriculture, were commerce and services. Other sectors such as mining, manufacturing, transport, construction, and public utilities were quite small (see Table 2-1 for further details).

This low level of industrial development was attributed to three factors. First, the unbalanced industrialization of East Africa during the colonial era; Kenya was the most developed by Britain among East African countries (Kenya, Uganda and Tanzania) [71]. Rweyemamu [74] concluded that Kenyan industrial prosperity hindered the industrial development of Tanzania. Second, the common external tariff policy of the East African countries [73]. Third, the lack of an indigenous capitalist class which could engage in industrial activity and lead industrial development.

2.1.1 The structure of industry:

Table 2-2, shows the extent of diversification in the economic structure in 1961. The agricultural-processing and mining industries earned 68 percent of the state's total industrial production per annum, about £12,020,000 and £4,765,000 respectively. The basic food processing industry and the consumer accounted for 10 percent and 4 percent respectively of industrial production. At that stage, import replacement of consumer goods had barely begun and the capital goods sector was virtually absent.

2.1.2 Labour productivity:

Based on a 1961 questionnaire, Silver [81], compares labour productivity to relative shares of wages in the net output. In an overall average (the industrial sector as a whole),

employees received in cash and kind 56.5 percent of net output. While, the ratio varied from one industry to another [80], it was judged that payments to employees were fair (i.e reflected their relative productivity).

2.1.3 The utilization of productive capacity:

According to an industrial survey on "productive capacity utilization" conducted in 1961 (just after independence), 38 percent of companies indicated that they were operating at full capacity [82]. Others are as detailed in Table 2-3. Reasons indicated by companies for under-utilization included: lack of consumer demand, ineffective utilization of raw materials, breakdown of machinery, lack of proper maintenance and services, effect of weather on supply (this was for the textile, food, beverage and sugar processing industries), inadequate transport and communications, stiff competition from cheap imports and lack of skilled labour.

2.2 Manufacturing industry after independence:

Two historical events took place during the period from independence to the 1980's that crucially affected industrial development in Tanzania. The first was the Arusha Declaration of 1967 [4,79] and the second event was "the Idi Amin War" of 1978-79 [88].

Table 2-1: Gross domestic products, 1961:

	Gross domestic products at factor cost (a)	
	£'000	Percentage
Agriculture	114,087	59.0
Commerce	22,239	11.5
Services	20,582	10.6
Transport	8,585	4.4
Rents	8,377	4.3
Manufacturing	6,958	3.6
Construction	5,840	3.0
Mining	5,476	2.8
Public utilities	1,360	0.7
Total(b)	193,504	100.0

(a) Figures may differ from other sources due to adjustments made to the census figures (census of industrial production 1961) when estimating gross domestic product. For details of these adjustments, see the United Republic of Tanganyika and Zanzibar, Central Statistical Bureau, The National Accounts of Tanganyika 1960-1962 (Dar-es-Salaam: The Treasury, 1964).

(b) Figures may not sum to the total due to rounding.

Source: United Republic of Tanzania, Background to the Budget: an Economic Survey 1966-67 (Dar-es-Salaam: Government Printer, 1966), Table 4, page 8.

Table 2-2: The structure of industry in Tanganyika in 1961:

	Number of establishments	Net output in 1961	
		Total £ thousands	% of total
Agricultural processing, mainly for export(a)	245	12,020	49
Mining, mainly for export(b)	31	4,765	19
Basic food processing and manufacture(c)	248	2,564	10
"Consumer goods"(d)	225	893	4
Motor vehicle repairs	86	336	1
"Industrial goods and services"(e)	87	876	4
Construction (private), bricks, stone quarrying, etc.	104	1,954	8
Electricity and water supply(f)	18	1,348	5
Total	1,044	24,756	100

(a) Sisal, tea, tobacco, cotton ginning, saw-milling.
(b) Gold, silver, tin, diamonds, mica, coal.
(c) Sugar, salt, dairy products, grain milling, bakeries, miscellaneous foods, beverages.
(d) Textiles, footwear, tailoring, woodworking, printing and publishing, rubber products, oil milling and soap, jewellery.
(e) Metal products, engineering and repairs, electrical repairing, and miscellaneous manufacturing (mainly goods for industry, but including meerschaum pipes and insecticides).
(f) 18 electricity generating establishments only; data on number of water supplying establishments not given.

Source: United Republic of Tanganyika and Zanzibar, Census of Industrial Production in Tanganyika 1961 (Dar-es-Salaam: Central Statistical Bureau, 1964), Appendix Table 1, page 87.

Table 2-3: Utilization of productive capacity, 1961:

Industry category	Percentage utilization
Metal goods	87
Woodworking	87
Sugar processing	84
Electricity	78
Printing	75
Miscellaneous foods	75
Lime	50
Oil processing	50

Source: M.S. Silver, The Growth of Manufacturing Industries in Tanzania. Westview Press, Inc. USA 1984, pages 84-85.

The Arusha Declaration enunciated the embarkation on a state policy of "socialism and self-reliance" The state took immediate control of seven major industrial companies in Tanzania and shifted the entire focus of ownership and investment in industry from the private sector to the public sector. The Idi Amin war was between Tanzania and neighbouring Uganda. The main objective was the ousting of dictator Idi Amin from Uganda. This was a costly exercise for a poor country like Tanzania, and was under-taken with little or no military or economic support from

other nations. These two events adversely affected Tanzanian economic growth.

2.2.1 Manufacturing Production, 1961 to 1965:

Table 2-4 shows an increase in net output in manufacturing and handicrafts from 1960 to 1965. Other industrial sectors experienced difficulties or lower growth rates over the period. This rapid growth in the output of the manufacturing sector relative to other sectors was partly due to establishment of more industries. For example, in the first four years following independence (1961-1965), 155 firms in manufacturing and agricultural processing industries employing ten or more persons were established. Thus, some growth in industrialization was evident in Tanzania during this period.

2.2.1.1 First Five Year Plan (FFYP) 1964-1969:

The FFYP was a conventional development plan with an emphasis on industrial development largely through private investment supported by Government infrastructure, incentive and minority participation (note that this was pre-Arusha Declaration). The FFYP implied acceptance of a high dependence on foreign initiatives, and development of agriculture largely within the context of the existing rural economic structure. The major policy objectives were:

(i) Promoting rapid growth through increased agricultural

output, based on the improvement of the productivity of traditional methods, coupled with gradual transformation into more capital intensive agriculture

(ii) Structural change by promoting import-substituting industries

(iii) Enhancing the socio-economic infrastructure

According to Rwegasira, Green and Arkadie [70], the plan involved some experimentation in the creation of more institutions and a much higher degree of ambition, in terms of the expansion of investment programs and the target rate of economic growth, than had been experienced before.

When introducing the FFYP to Parliament, President J.K. Nyerere aptly observed:

> **"Simply to expand agricultural output, however, would be to condemn Tanganyika to a position of permanent economic inferiority in the world. We must have more balance in our economy, and end this absolute reliance on the prices of primary commodities. We must have an industrial base to our economy. Only when we have this will our future be to some extent safeguarded"....[66].**

In order to accomplish this objective, the FFYP was intended to establish a strong industrial base and to encourage import substitution linked with export promotion. But both import substitution and export promotion require substantial amounts of resources. Thus, the availability of basic

materials became a major factor in forcing decisions about which industries to establish.

A remarkable economic incentive, part of the FFYP, was tax relief for newly established firms [30]. This provision, plus other incentives, attracted many private and foreign investors and many new firms were established.

2.2.2 Manufacturing Production, 1965 to 1980's:

In February 1967, the State took control of seven major companies and put them under a holding corporation called the National Development Corporation (NDC). The companies are: BORA (the former BATA shoe Co.,), Kilimanjaro and Tanzania Breweries, CMB Packaging (the former Metal Box Co.,), Tanganyika Extract Co., BAT Tanzania Limited and Tanganyika Portland Cement [16].

The nationalization of these major companies in Tanzania was announced as part of "the Arusha Declaration" by the President J.K. Nyerere. The Arusha Declaration had much broader policy objectives than simply nationalizing six companies. These broader objectives may be summarized as following:

(a) overcoming absolute poverty and redistribution

(b) mass participation and public sector leadership

Table 2-4: Gross domestic products, 1960-1965:

Sector	Net output at constant price, shs. million					
	1960	1961	1962	1963	1964	1965
Agriculture, hunting forestry and fishing	2,256	2,047	2,171	2,232	2.517	2,471
Mining and quarrying	104	111	105	87	97	112
Manufacturing and handicrafts	109	135	146	158	168	190
Construction	91	111	113	114	114	119
Electricity and water	25	26	29	29	30	31
Transport, storage and communications	175	174	186	182	202	209
Commerce, rent and services	941	961	1,030	1,027	1,115	1,179
Total	3,701	3,544	3,796	3,951	4,209	4,324

(a) Includes subsistence and money sectors, private and public.

Source: United Republic of Tanzania, Central Statistical Bureau, Statistical Abstract 1966 (Dar-es-Salaam: Ministry of Economic Affairs and Development Planning, 1968) Tables Q2, page 143, Q3, page 144, and Q7, page 149; United Republic of Tanzania, Bureau of Statistics, National Accounts of Tanzania 1964-1972 (Dar-es-Salaam: Ministry of Economic Affairs and Development Planning, February 1974) Table 7, page 20.

(c) growth and balance of economy

(d) economic restructuring

According to President Nyerere, economic development in Tanzania up to 1967 had resulted in;

> **"An increase in the amount of economic inequality between citizen, and this was leading toward attitudes of social inequality. ... The country was beginning to develop an economic and social *elite* whose prime concern was profit for themselves and their families, and not the need of the majority for basic living standards. We were beginning to see the development of a true class system" [65].**

Cranford Patt argued that in Tanzania in 1967, there were no substantial social classes to justify socialist initiatives [68]. But Professor Issa Shivji views the 1967 nationalization positively and believes that it was necessary to prevent the control of the economy by the petty bourgeoisie bureaucracy [77].

In several cases the foreign owners continued as minority shareholders, sometimes with managerial responsibilities. Some investors did not comply with the Government policy. Thus, following the Arusha Declaration there was an exodus of foreign expertise.

The period 1967-75 was characterized by a rapid expansion of the parastatal sector. As a result of the nationalizations in 1967, the assets of manufacturing parastatals increased at a stroke by Tsh 134 million, and the assets of manufacturing parastatals with Government majority shares increased from Tsh 21 million in 1964 to Tsh 971 million in 1971 [76]. Investment by parastatals rose from 13 percent of total manufacturing investment in 1966 to more than 63 percent in 1970.

Table 2-5 shows that the contribution of parastatals to manufacturing investment rose from 26.5 percent in the period 1966-69 to 55.4 percent in the period 1970-73. However, the highest levels of parastatal investment were reached in 1970, and thereafter started to fall substantially.

In the second half of 1970's, manufacturing production growth deteriorated, and the main reasons were:

a) increases in oil prices, 1974-75 and 1979*
b) falling or stagnant prices of the state's export commodities.

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* This deterred the country's capacity to import, including inputs for industries.

Table 2-5: Fixed Capital Formation in Manufacturing Parastatals Compared to Total Manufacturing Industry at Constant (1966-73) prices:

	Total manufacturing industry Tsh million	Manufacturing parastatals Tsh m.	Parastatals as % of total
1966	153	20	13.1
1967	174	60	34.5
1968	206	44	21.4
1969	151	57	37.8
Total 1966-69	684	181	26.5
1970	281	179	63.7
1971	266	147	55.3
1972	184	91	49.5
1973	204	101	49.5
Total 1970-73	935	518	55.4
Percent change 1966/69-1970/73	36.7%	186.2%	

Source: World Bank,"Basic Economic Report": Annex V; National Accounts of Tanzania 1964-1972, Dar-Es-Salaam, 1974; and National Accounts of Tanzania 1966-1980, op. cit. Fixed capital formation at current prices has been deflated to 1966 prices by using the implicit deflator for total capital formation in the National Accounts.

c) the break-up of the East Africa Community in 1977**

d) the war with Uganda.

2.2.2.1 Labour Productivity:

Employment in manufacturing parastatals tended to grow at a higher rate than value added in output in the period 1966 to 1973. Thus, productivity of labour in terms of value added per worker declined. According to M.S. Silver, in the period 1966-72, the parastatals manufacturing sector was characterized by an increasing unit wage bill stemming from decreasing labour productivity. This structure eroded the gains made by the success of the incomes policy, a measure which had succeeded in maintaining relatively stable average wage and salary levels over the period 1966-72. The wage and salary bill increased in money terms by 52.7 percent per annum over the period 1966 and 1972 principally because of the rapid increase in the number of employees in manufacturing parastatals [83]. M.S. Silver suggests that the fall in labour productivity and rise in employment may be attributed to the substitution of labour for capital in existing firms and/or the newer firms being more labour-intensive than older firms. However, he admits that there

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** This forced the country to use a large part of its investment capacity to establish the economic services formerly provided on an East African basis, including: airlines, post and telecommunications, railways, road transportation, research institutes and harbours.

is no empirical evidence giving support to such an explanation [84].

S. Kim, in a study covering the period 1970-75, compared the performance of parastatal with private manufacturing establishments by estimating production functions for four industries based on data for 35 firms pooled over five years. Evidence was found of lower efficiency for parastatals compared with privately owned establishments in the same industry [43].

2.2.2.2 Capacity Utilization:

President J. K. Nyerere, in his book called "The Arusha Declaration, Ten years After" in 1977, addressed the capacity under-utilization issue when he said:

> **"...Almost all our industrial plants are running well below capacity; sometimes less than 50 percent of what could be produced with existing machinery is actually manufactured and put in market! Even the Tanzania Breweries was only using 68 percent of its capacity in 1975; Tegry Plastics ran at 46 percent capacity and the Mara Milk Plant at less than 30 percent capacity. Further, the Wazo Hill Cement Works are certainly not producing anything like the amount of cement it could do if it were working properly and the textile mills could probably do better also. In 1975 at least, Bora Shoes were not only producing a much lower quantity than their machinery justified but they were also producing shoes of low quality... Over the last ten years we have done quite well in spreading basic social services to more and more people in the rural areas. More remains to be done; but we shall only be able to do it if we produce more wealth. And we have not been doing very well on that front"... [67].**

The capacity under-utilization has been attributed to the following factors:

- energy supply shortages
- raw materials supply shortages
- foreign exchange constraints
- bureaucratic complications
- spare parts supply shortages
- skilled labour shortages
- plant maintenance inadequacies
- poor management
- water shortages
- energy shortages

3.0 Survey Results:

3.1 DESCRIPTION OF SURVEY METHOD EMPLOYED

Much of the information on capacity and spare parts shortages comes from newspapers and politicians. There is little direct hard data. To remedy this, a field survey was conducted. The questionnaire solicits data and opinions from Tanzanian maintenance managers on the problem of availability of industrial spare parts.

Field work was started in June 1990, and ended in October 1990. As well as numerous interviews with maintenance managers, experts and an official from the ministry of industry, the main instrument employed was a questionnaire in English of forty six questions (see examples in Appendix i). A random sample of 59 industries was generated from the national telephone directory. Unfortunately, not all the industries which appear in the directory were operational, and also not all industries were registered. Therefore, the list of industries had to be reviewed. After a dialogue with an official from the ministry of industries about the suitability of the sample, some industries which were involved in the Government's workshop survey were recommended. These added industries were not randomly selected because the official relied on his personal experience that these industries may provide adequate data. Firms selected "called" to get those that represent "best

practices". This may not reflect conditions of most Tanzanian industries. The final sample consisted of 40 industries located in seven regions. It was about 8% of all Tanzanian industries.

Most industries surveyed are located in Dar-es-Salaam. This is because most industries are in Dar-es-Salaam. It was difficult to survey many industries in other regions due to transportation problems, financial constraints and limited time. Thus, the data is from mainly medium sized, Dar-es-Salaam industries, but these are the model form of Tanzanian industry.

The author personally visited twenty five companies, located in Dar-es-Salaam, Tanga and Coast regions (see Table 3-1), and discussed with maintenance managers the problems and the possible solutions to the spare parts problem. To achieve a good response rate, the author decided to discuss some questions directly with maintenance managers. Also, it was assumed that many industries would not return questionnaires in time, and thus picking dates were arranged. The rest of the industries (out of Dar-es-Salaam), were sent questionnaires by post. The author managed to collect 65% of the questionnaires, and many opinions of the industrialists. The companies responding represent about 5% of all Tanzanian industries employing at least 15 employees.

3.1.1 Survey Coverage:

Table 3-1 shows a number of industries responded to the questionnaire according to regional locations. The return of mailed questionnaires was poor, except for those mailed to industries in Tanga region. Thus, with regard to the survey time frame (about 3 months), the procedure proved to be quite inefficient. The procedure of interviewing the maintenance managers was very successful; 95% of questionnaires distributed in Dar-es-Salaam were collected.

Table 3-1: Coverage of Towns Surveyed:

Region	No. of questionnaires distributed	No. of industries interviewed	Questionnaires received
Dar-es-Salaam	28	23	22
Coast	2	1	1
Tanga	4	1	3
Morogoro	3	-	-
Arusha	1	-	-
Mwanza	1	-	-
Kilimanjaro	1	-	-
TOTAL	40	25	26

3.1.2 Survey Conduct:

During the survey, a general observation was that a considerable number of maintenance managers were willing to answer questions. However, some of them were reluctant to

provide financial data of their industries; the important data were considered as confidential. Some privately owned companies were not co-operative and in some cases even reluctant to provide specific appointment dates. Though the introduction letter from the ministry of industry to these companies indicated that the study was not politically biased, they still expressed concerns about the confidentiality of the results. They feared the information may be used for the Governments interests. In these cases, no attempt was made to persuade them because it was felt that their answers would not be very useful.

The reliability of responses given by interviewees is one of the concerns. There is always the problem of errors and deliberate biases. In some cases, those interviewed either did not understand the questions or merely wanted to get rid of the interviewer. For example, one maintenance manager spent about 30 minutes to answer the questionnaire (that is 39 seconds for each question). I couldn't drop this questionnaire from my sample because the validity of data is judged during the analysis.

Some of the mailed questionnaires were returned either partly filled or unfilled. This suggests that, either the questions were not understood or the managers did not want to answer the questions. However, the author's general

experience was that of enthusiastic people attempting to honestly answer the questions so there is no basis to suspect that the data is not valid.

The following results are based on the completed questionnaires. Each question will be stated and the answers from twenty six industries will be summarized.

Q1. Number of employees:

The number of employees in any one company ranged from 15 to 3900 people. See Table 3-2 below:

Table 3-2: SIZE OF COMPANIES

Size of the Company	Number of Companies that responded
i. Small (Less than 100 Employees)	4
ii. Medium (100 - 600 Employees)	16
iii. Large (Above 600 Employees)	6

Q2. What industrial category does your company belong? (e.g Engineering, chemical industry, etc).

See Table 3-3.

Table 3-3: TYPES OF COMPANIES

Industrial Category	Number of industries
1. Engineering	13
2. Chemical	4
3. Food and beverage	3
4. Textile	1
5. Wood processing	1
6. Paper processing	1
7. Radios & electric	1
8. Cement manufacture	1
9. Paper-printing	1
TOTAL	26

Q3. What are your main products/services?

A wide range of products were reported; from manufacturing companies there were products such as footwear, rubber parts, paper boards, packets and sacks, tin cans, crown caps, plastic pipes, utensils and kitchen wares, storage tanks, steel structures, non-motorized farm implements, iron sheets, steel bars, portland cement, cigarettes, pipe tobacco, a variety of radios, processed tea and coffee.

Engineering workshops offer services such as: manufacturing of spare parts on a jobbing basis, reconditioning of spare

parts and tools, oil cleaning, consultancy, inspections and repairs.

Q4. Do you export some of your products? Yes No

If Yes, please list the products and countries you export to.

Fifty percent of the industries export their products. The details are as below Table 3-4:

Table 3-4: PRODUCTS AND COUNTRIES EXPORTED TO:

Products	**Countries exported to**
Radios, dry cells	Rwanda, Burundi
Steel sheets	Kenya, Burundi, Rwanda, Zambia, Zimbabwe and Uganda.
Galvanized sheets	Burundi
Aluminium circles	Nigeria, United Kingdom, Zaire, Ethiopia, Kenya, Burundi, Zimbabwe and Uganda
Fabrics	Bulgaria and Mozambique
Yarns	West Germany and China
Timber	Middle East
Processed Tea and Coffee	Sweden, Finland and Sudan
Cigarettes	Uganda, Burundi and Zaire
Cooking pans	Sweden
Portland cement	Uganda, Kenya, Burundi and Angola

Q5. At what capacity is your company working presently?

The median capacity utilization is between 48 to 58 percent. See Table 3-5 and Figure 3-1.

Table 3-5: CAPACITY UTILIZATION: 1990

Capacity Utilization	Industries	
	Number	Percent
15 - 25%	3	13
26 - 36%	3	13
37 - 47%	3	13
48 - 58%	6	25
59 - 69%	5	20
70 - 80%	4	16

Mean = 51%

Range = 65%

Q6. What is the installed working capacity?

Nineteen out of twenty six companies surveyed gave answers, while seven did not. The figures were reported in terms of annual production.

Q7. Do you often meet your performance targets? Yes No

Six out of twenty six companies surveyed indicated that they meet their targets.

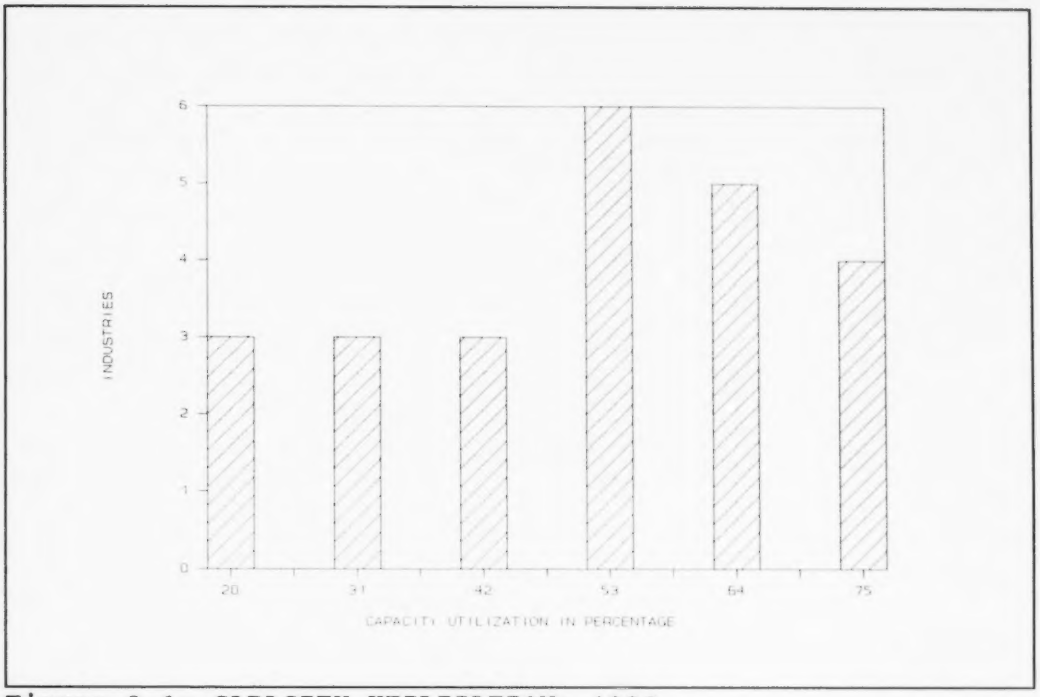


Figure 3-1: CAPACITY UTILIZATION: 1990

Q8. Indicate reasons which may cause target shortfall

See Table 3-6 and Figure 3-2.

Table 3-6: REASONS FOR TARGETS SHORTFALL

Reasons	Number of Industries
A. Shortage or delay of raw materials	18
B. Breakdown of machinery	13
C. Lack of spare parts	11
D. Power outage or fluctuations	11
E. Marketing of products	5
F. Water shortage	3
G. Lack of skilled staff	3

Table 3-6 (continued)

Reasons	Number of Industries
H. Financial constrains	2
I. Lack of sufficient orders	2
J. Lack of favourable motivation to workers	2
K. Unfavourable management	1

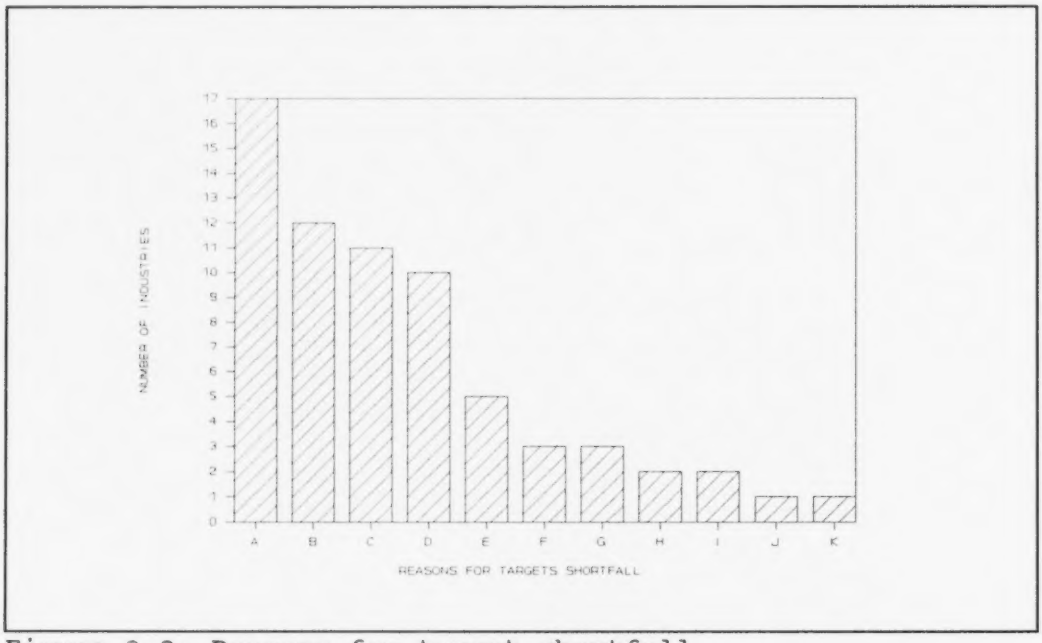


Figure 3-2: Reasons for target shortfall

Q9. Is one of the following a problem in your company operations?

See Table 3-7

Table 3-7: OPERATIONS PROBLEMS

Description of the Problem	Percentage of Companies Agreed
a). Lack of Spare Parts	79
b). Age of Machinery and Equipment	88
c). Water Shortage	29
d). Lack of Modern Technology	62
e). Raw Materials	79
f). Electricity Shortage	58
g). Frequent Machine Breakdown	75
h). Marketing Strategies	42
i). Inexperience of Personnel	50

Q10. Rank the top five of the problems in order from worst to best. See Table 3-8.

Table 3-8: Problems ranked in order from worst to best:

Definition of the problem	Ranking according to industries responded in (%)				
	Worst	I	II	III	Best
a. Lack of spare parts	26	22	9	9	0
b. Age of machinery and equipment	13	13	35	13	15
c. Water shortage	13	4	0	9	5
d. Lack of technology	4	0	17	13	15
e. Lack of raw materials	22	26	9	9	10
f. Electricity shortage	4	13	4	9	10
g. Machine breakdown	0	9	13	30	25
h. Marketing strategies	13	13	9	4	0
i. Inexperience of personnel..	4	0	4	4	20

Q11. Are there problems with spare parts? Please list the three main ones. See Table 3-9

Table 3-9: SUMMARY OF SPARE PARTS PROBLEMS:*

Description of the Problem	Industries Responded
1). Lack of raw materials (steels, Brass, etc)	33%
2). Lack of technology	33%
3). Delay in supply of spare parts	25%
4). Lack of drawings	17%
5). Low quality	17%
6). Inaccuracy of machine tools	17%
7). Provision of Foreign Currency	13%
8). Lack of Machinery and Equipment for Manufacturing and Testing	13%
9). Obsolescence	13%
10). Technical skills	13%
11). Lack of Working Tools	8%
12). Liquidity	8%
13). Standardization	4%
14). Different Dimension Versions	4%
15). Unable to Obtain Parts from the Manufacturer	4%
16). Communication	4%
17). Material Specifications	4%

Q12. Please suggest solutions to the problems you have mentioned above.

* **The responses include companies which manufacture spare parts and those which don't manufacture.**

The maintenance managers have suggested the following remedies to problems related to the provision of spare parts:

a). Coordination between the Government agency (The ministry of industry) and local spare parts manufacturers, by making raw materials, tools and other resources available, so that more spare parts could be manufactured locally.

b). Streamlining the import procedures in order to shorten lead times, after the foreign exchange is available.

c). To Boost the export of industrial products in order to earn more foreign exchange, which could be used for payment of imported spare parts.

d). Restructuring of the existing workshops, by providing them with sufficient machine tools and equipment, so as to improve their capabilities on manufacturing of spare parts.

e). To improve the quality of manufactured products in order for them to be competitive in the market.

f). To replace the unqualified top management with qualified managers.

g). Systematic replacement of aging and obsolete equipment.

h). The problem of lack of special steels should be dealt with at Government level, by establishing those which are in great demand, and arrange to import them, so that they can be available locally.

i). To develop raw material base.

j). To order spare parts and materials from supplier with a reputation in supplying quality products.

k). The Government in collaboration with manufactures, suppliers and spare parts consumers should help to establish specialized centres for production and reconditioning spare parts which require specialized technology and technical skills.

l). To maintain an economic order quantity when placing orders.

m). To train the technical personnel in modern manufacturing technology, in order to cope with ever-increasing technological changes.

n). Workers should be motivated by providing good working conditions, salaries and involvement in decision making.

o). Modification of some machines, in order that they could accommodate standard spare parts.

p). Proper maintenance of machines, e.g overhaul, in order to maintain the machines in good working conditions.

q). To improve the existing spare parts storage systems.

r). Whenever possible, spare parts should be supplied together with engineering drawings.

s). Raw materials should be supplied together with their technical specifications.

t). Foreign currency should be sought to purchase the spare parts abroad.

Q13. Do you agree that spare parts consumption depends on the quality of maintenance work?

Disagree Least Agree Agree Strongly Agree

The results were summarized as below Table 3-10 and Figure 3-3:

Table 3-10: OPINION ON SPARE PARTS CONSUMPTION

The opinion	Number of industries responded
Strongly Agree	15
Agree	10
Least Agree	0
Disagree	1

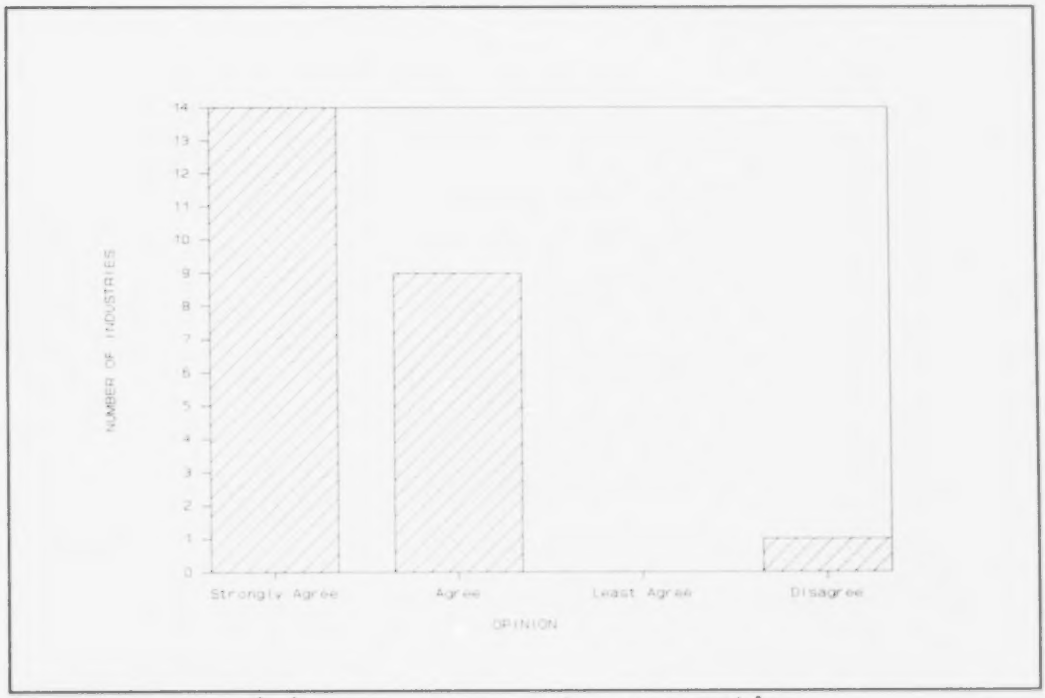


Figure 3-3: Opinion on spare parts consumption

Q14. The age of machinery and equipment is related to high spare parts consumption. Do you agree?

The results are summarized in Table 3-11 and Figure 3-4:

Table 3-11: OPINION ON SPARE PARTS CONSUMPTION

The opinion	Number of industries responded
Strongly Agree	13
Agree	10
Least Agree	2
Disagree	1

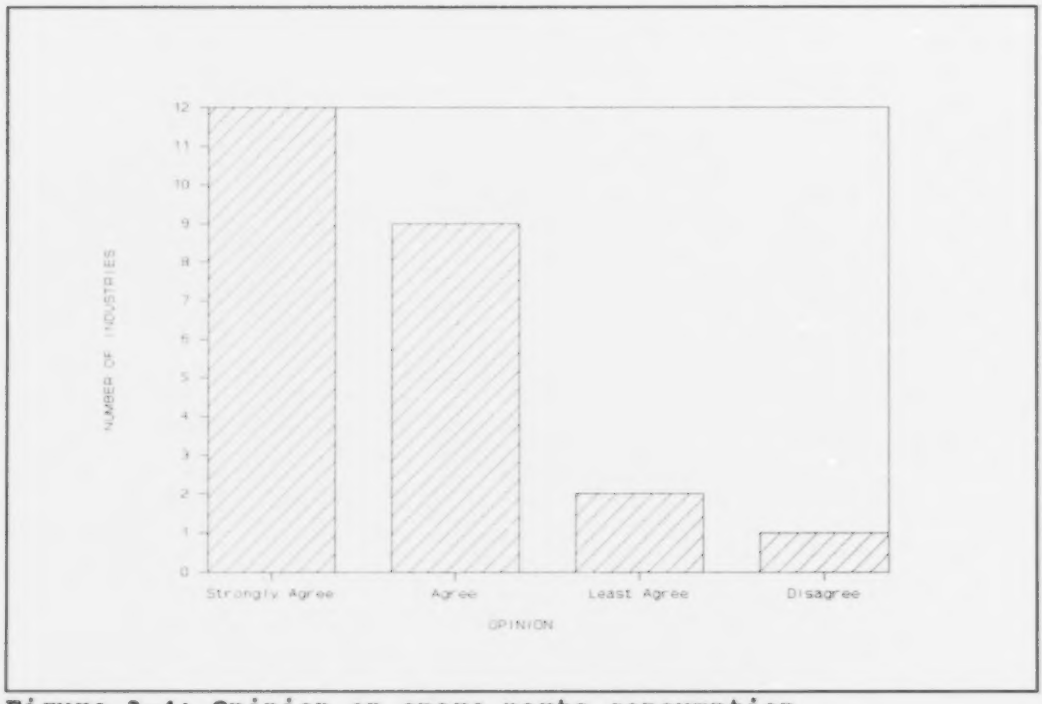


Figure 3-4: Opinion on spare parts consumption

Q15. Does Inventory Management influence the availability of spare parts in your company. Do you agree ? See Table 3-12 and Figure 3-5.

Table 3-12: OPINION ON AVAILABILITY OF SPARE PARTS

The opinion	Number of industries responded
Strongly Agree	7
Agree	13
Least Agree	6
Disagree	0

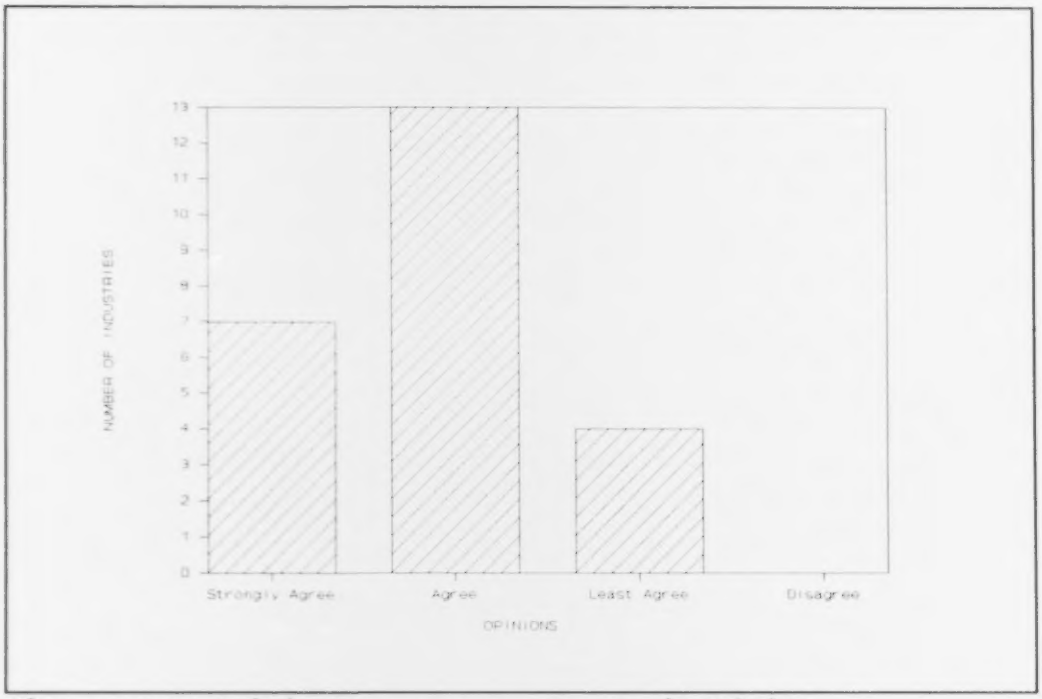


Figure 3-5: Opinion on spare parts availability

Q16. Do you still obtain spare parts required for your machines from their manufacturers? Yes No

If the answer is No, Please indicate where you get them.

About 85 percent of the industries responding, indicated that they obtain some of their spare parts requirement from the machinery manufacturers, while 15 percent, no longer do.

Q17. What percentage of annual spare parts requirements can you obtain locally? See Table 3-13 & Figure 3-6.

Table 3-13: SPARE PARTS OBTAINED LOCALLY

PERCENTAGE	NUMBER OF INDUSTRIES
0 - 20	12
21 - 41	3
42 - 62	3
63 - 83	2
84 - 100	6
TOTAL	26

Q18. Please comment on the capabilities of your workshop:

a). Operations

b). Types of spare parts manufactured

c). Capacity

Two companies indicated that they do not have machine shops. Among those which have maintenance workshops, only twenty two out of twenty four industries gave answers. See Table 3-14:

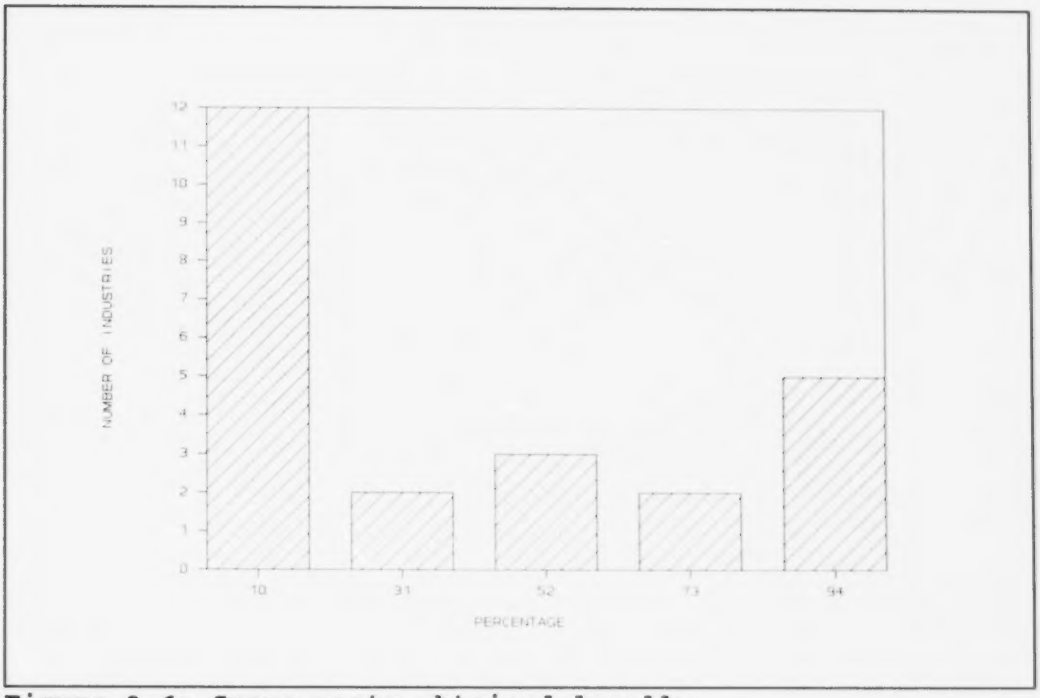


Figure 3-6: Spare parts obtained locally

CAPACITY:

The question was not well understood. Twelve out of twenty two companies did not answer at all. However, of those that answered, three of them answered in terms of capacity utilization in percentage; the annual capacities are between 20 to 40 percent. Three industries gave their figures in terms of annual steels consumption.
See Table 3-16. While the rest, just commented that their capacities are quite small.

Table 3-14: WORKSHOP OPERATIONS

Operations	Number of workshops have:
Conventional machining	
e.g. turning, boring, grinding, shaping, etc	22
Welding	22
Steel fabrication	12
Casting	6
Forging	3
Metal spray	3
Spark erosion	1
Panel beat	1
Heat treatment	3

Table 3-16: WORKSHOP CAPACITY

Company	Annual steels consumption in (tons)		
	Machine shop	Foundry	Steel shop
1. NECO	150	400	600
2. UFI	1500	NA	NA
3. SRM	12	NA	NA

Table 3-15: SPARE PARTS MANUFACTURED

Machined parts:	Casted parts:
Gear group	Gears
Spur	Pulleys
Helical	Bearing blocks
Worm	Aluminium parts
Bevel	Sprockets
	Wheels
Shaft group	Sleeves
Cylindrical shafts	
Step shafts	
Screw shafts	
Others	
Bolts & nuts	
Pulleys	
Bushes	
Simple moulds	
Pins	
Rollers	
Brackets	
Sprockets	

Q19. What are the spare parts manufacturing problems in your workshop? See Table 3-17 and Figure 3-7.

Table 3-17: SPARE PARTS MANUFACTURING PROBLEMS

The problem	Number of industries responded
A). Lack of proper raw materials	13
B). Lack of working tools	8
C). Lack of skilled workers	6
D). Inadequate machine tools	6
E). Lack of specialized equipment	5
F). lack of modern technology	4
G). Inaccuracy of machines	3
H). Frequent machine breakdown	4
I). Age of machinery	4
J). Unavailability of heat treatment facilities	3
K). Lack of Engineering drawing	2
L). Lack of material specifications	2
M). Lack of measuring instruments	3
N). Lack of modern machine tools and equipment	2
O). Long lead time to secure materials and parts	2
P). Different dimension versions	1
Q). Lack of material testing facilities	1
R). Quality of jobs	1

** The responses don't include all companies. Only those which have internal machine shops and engineering workshops are concerned. Therefore, the results should not be confused with those in Table 3-9 which included all companies.

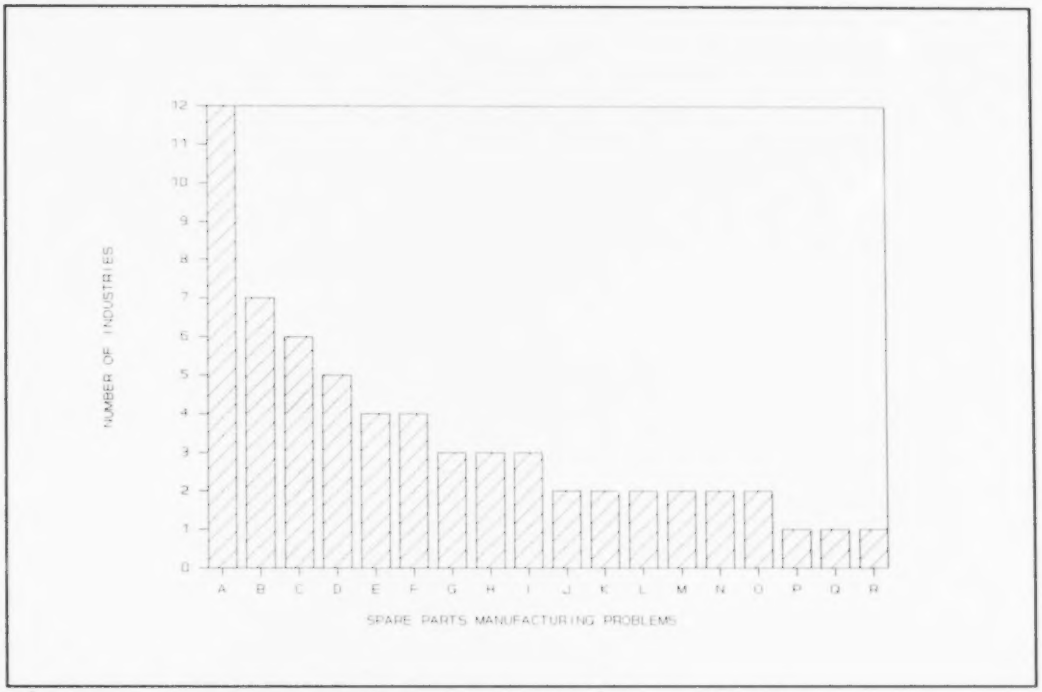


Figure 3-7: Spare parts manufacturing problems

Q20. What in your opinion, could be the possible solutions to the above problems?

The following opinions were addressed by maintenance managers:

1. Gradual localization of technology transfer.

2. To boost up sales in order to get more money, which would be used for purchasing workshops inputs.

3. To develop industrial maintenance awareness at all levels.

4. Investing in modern equipment which could work faster and be more accurate than the old equipment.

5. Emphasize training of personnel at all levels.

6. Acquisition of proper technology and know how in the whole process of spare parts production.

7. To improve working conditions for workers, by providing incentives such as good salaries, training opportunities and encourage innovation.

8. To make raw materials available in the local market.

9. To improve the existing foundries, so that they can produce more and quality casted spare parts.

10. To improve the quality of local spare parts.

11. The local machine tools manufacturing company, Kilimanjaro Machine Tool Manufacturing Company (KMTMCO), should not only produce machine tools but also tools, measuring instruments and some workshop equipment, in order to improve their availability locally.

12. The Government should encourage private investment.

13. Rehabilitation of the existing aged machinery.

14. Raw materials should be supplied together with their specifications.

15. Engineering drawings should be filed properly for future needs.

16. The Government should assist local companies in acquiring tools, materials, technology and training required for spare parts manufacture.

17. Proper maintenance plans should be followed and maintained, in order to improve availability of machines and equipment.

18. Proper allocation and utilization of manpower.

19. Proper allocation of foreign exchange, and streamlining ordering procedures.

Q21. What types of raw materials are you using in the manufacturing of spare parts? Please specify, together with sources.

E.g. Steels: 1). Low carbon steel; National steels (NS)

2). Stainless steel; Imported, NS, etc.

See Table 3-18.

Table 3-18: SPARE PARTS RAW MATERIALS AND THEIR SOURCES

Type of material	Number of Industries responded	
	SOURCE	
	Imported	Local
1. Low and medium carbon steels	4	13
2. Alloy steels (special steels)	7	4
3. Brass and bronze	7	7
4. Stainless steels	5	1
5. Copper	2	1
6. Plastics	1	0
7. Spring steels	1	0
8. Lead ingots	1	0
9. Ferro-phosphorus	1	0
10. Ferro-silicon	1	0
11. Stellite	1	0
12. Titanium	1	0
13. PVC	1	0
14. Nylon	1	0
15. Bekalite for insulation purposes ...	1	0
16. Aluminium plates and shafts	1	0

Q22. What types of machine tools and equipment would you think, had they been available in your workshop could have enabled you to manufacture most of your spare parts requirements? See Table 3-19.

Table 3-19: MACHINE TOOLS AND EQUIPMENT REQUIREMENTS

Type of machine tool or equipment	Number of industries
1. Surface grinder	9
2. Universal milling machine	8
3. Radial drill	7
4. Heat treatment facility	7
5. Cylindrical grinder	5
6. Broaching machine	4
7. Gear hobbing machine	4
8. Metal casting equipment	4
9. Modern lathe machine	4
10. Honing machine	2
11. TIG welding equipment	2
12. N.C lathe machine	2
13. N.C milling machine	2
14. C.N.C lathe machine	2
15. Gear shaper	2
16. Spark erosion machine	1
17. Jig boring machine	1
18. High capacity power press	1
19. Shaping machine	1

Table 3-19 (continued)

Type of machine tools or equipment	Number of industries
20. Crankshaft grinding machine	1
21. Vertical polishing machine	1
22. C.N.C milling machine	1
23. Gang drill	1
24. Wheel tyre (steel) rolling mill	1
25. Axle forging press	1
26. Screws making machine	1
27. Large gears generating machine	1
28. Induction furnace	1
29. Testing and measuring equipments	1

Q23. Please list some of the spare parts, and manufacturing technologies involved, which you are importing from abroad? See Table 3-20.

Table 3-20: SPARE PARTS IMPORTED AND TECHNOLOGIES INVOLVED

Type of spare part	Technology involved
1. Different types of bearings (ball, pin and roller)	Specialized bearing technology
2. Rubber seals and o-rings	Rubber moulding or casting
3. Intricate metal castings	Casting and machining

Table 3-20 (continued)

Type of spare part	Technology involved
4. Shoe lasts (foot form) and mould	Specialized shoe technology
5. Springs (coil and leaf)	Specialized technology
6. Steam flexible pipes	Specialized technology
7. Metal cutting tools	Machining and heat treatment
8. Hydraulic and pneumatic equipments	Specialized technology
9. Plastic parts	Injection moulding
10. Electronic boards and components	Specialized technology including micro welding
11. Propeller shafts	Forging, welding and machining
12. Fuel injection pumps	Specialized casting and machining
13. Various engine parts	Casting, forging, machining and heat treatment
14. Electrical equipments e.g. contactors, switches, etc	Polymer processing for insulation
15. Various forms of gears	Casting, machining and/or heat treatment
16. Galvanizing kettle and soldering bath	Fabrication by welding

Table 3-20 (continued)

Type of spare part	Technology involved
17. Locomotive wheel tyre	Die forging and machining
18. Locomotive axles	Die forging and machining
19. Impellers for pumps	Casting and machining
20. Front snap guard	Casting and machining
21. Temple box	Machining
22. Blanking tools	Precision machining and heat treatment
23. Hooking blade	Precision machining
24. Chains	Shearing, machining and heat treatment
25. Rubber belts	Vulcanization
26. Gauges	Specialized technology
27. Crankshaft	machine forged and machined
28. Cylinder heads/blocks	Ground and chrome-plated

Q24. Which technologies (mentioned above) are not available in the country (in engineering workshops)?

Table 3-21: TECHNOLOGIES NOT AVAILABLE

1. Bearing manufacturing
2. Moulding of intricate shape parts
3. Electronic boards and components production
4. Polymer processing for insulation purposes
5. Vulcanization
6. Hydraulic and pneumatic equipments manufacturing
7. Manufacturing of various engine parts, e.g. pistons and rings, crankshafts, cams and followers, valves, etc
8. Fuel injection pump manufacturing
9. Die forging
10. Some modern welding technology, e.g. GMAW, friction welding and leaser beam welding.
11. Steam flexible pipes making.
12. Heavy casting-over 500 kgs capacity.

Q25. Do you think that if those technologies are imported into the country, most of industrial spare parts could be manufactured locally? Yes No If No, why?

About 77 percent of the companies responding, said Yes to the question of import of technology into the country, for the manufacture of spare parts locally, while 23 percent did not comment. See Table 3-22 and Figure 3-8.

Table 3-22: OPINION ON IMPORT OF TECHNOLOGY

The opinion	Industries responded
a). Yes	77%
b). No	0
c). No comments	23%

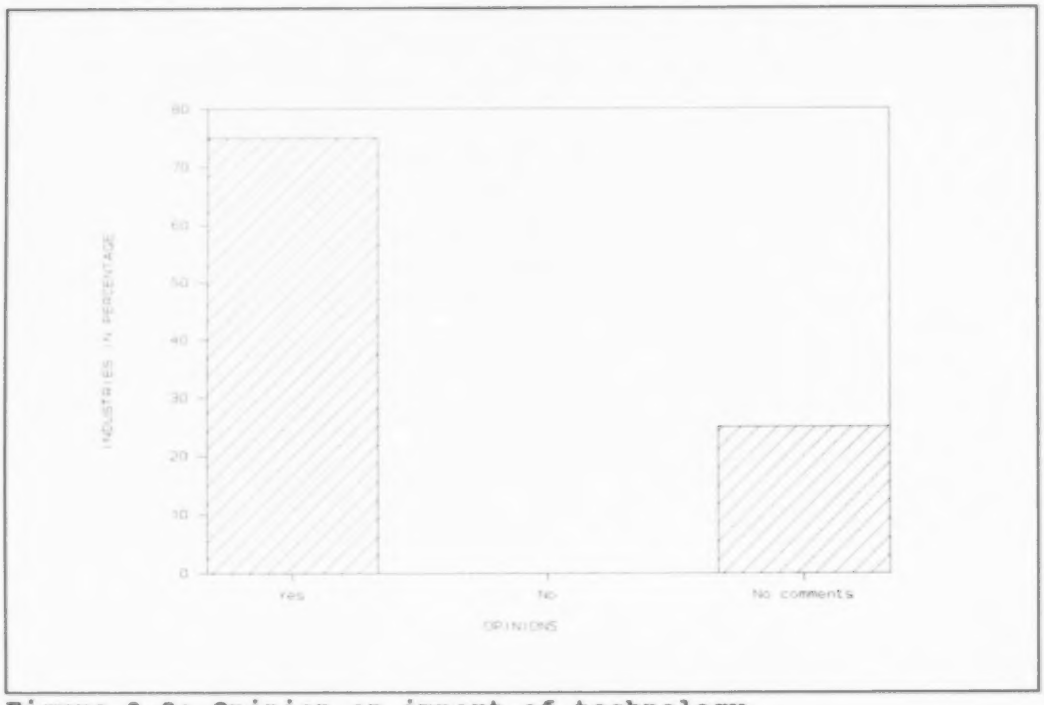


Figure 3-8: Opinion on import of technology

Q26. What other factors do you think should be considered with regard to spare parts manufacturing in the country?

The Tanzanian maintenance managers interviewed, suggested the following considerations:

(a) The Government should help local manufacturers, in obtaining raw materials, equipment, training and motivating people, so that they can produce parts of high quality at competitive prices.

(b) Coordination among engineering workshops and other industries, in order to understand the capacity and capability of each workshop, so that certain spare parts could be made by a particular workshop.

(c) There should be maintenance workshops, as it is now, in every firm, and zonal specialized workshops, to cater to the manufacture of special spare parts.

(d) Nation wide survey of spare parts demands should be conducted, in order to establish those which could be manufactured locally.

(e) In order to avoid duplication of efforts, subcontracting to expert workshops should be encouraged, so as to get the best results out of the resources that are available presently, in the country.

(f) Each industry should have a well-stipulated training program for development of its technical personnel.

(g) The Government should support those workshops which are involved with spare parts production, by providing training to management staff, technical personnel, and ascertain the need for importing some parts. Those parts which can be manufactured locally should not be permitted into the country.

(h) Industries should look into effective marketing strategies.

(i) Precise training, in the form of either workshops, seminars or in-plant, on the manufacture of spare parts, should be emphasized.

(j) The Government should look into the high cost of raw materials; especially steels, so that they can be purchased at reasonable cost.

(k) To emphasize production of quality spare parts.

(l) Advertisement should be emphasized in order to bring awareness of services and new products offered.

(m) The existing central workshops should be improved, by investing in modern machines, and better services.

(n) To improve the quality of spare parts manufactured, by introducing modern machine tools and equipment.

(o) To improve marketing strategies, by establishing market promotion sections in each industry.

(p) Maintenance awareness should be promoted in regard to the use of machinery, fitting principles, storage, treatment, etc.

(q) Standardization of spare parts that can be accommodated by different machines should be promoted.

(r) To establish a number of mobile workshops, to identify problems in various industries.

(s) To establish a sound infrastructure, which will ensure prompt delivery of spare parts.

(t) As the quality of parts depends, primarily, on raw materials, there should be quality control for both imported and local raw materials.

Q27. What are the import procedures? Please explain from order processing up to receiving.

See Figures 3-9(a), (b) & (C):

Q28. What is the average lead time for ordering spare parts from abroad? (from order preparation, secure funds from bank up to when you receive)

Average lead time is six months. See Table 3-23 and Figure 3-10. But this will depend on the type of spare parts and the country supplying these parts.

Table 3-23: AVERAGE LEAD TIME

Lead time in months	Industries Responded
2 - 3	7
4 - 5	1
6 - 7	9
8 - 9	3
10 - 11	2
12 - 13	1
TOTAL	23

AVERAGE = 6 MONTHS

RANGE = 10 MONTHS

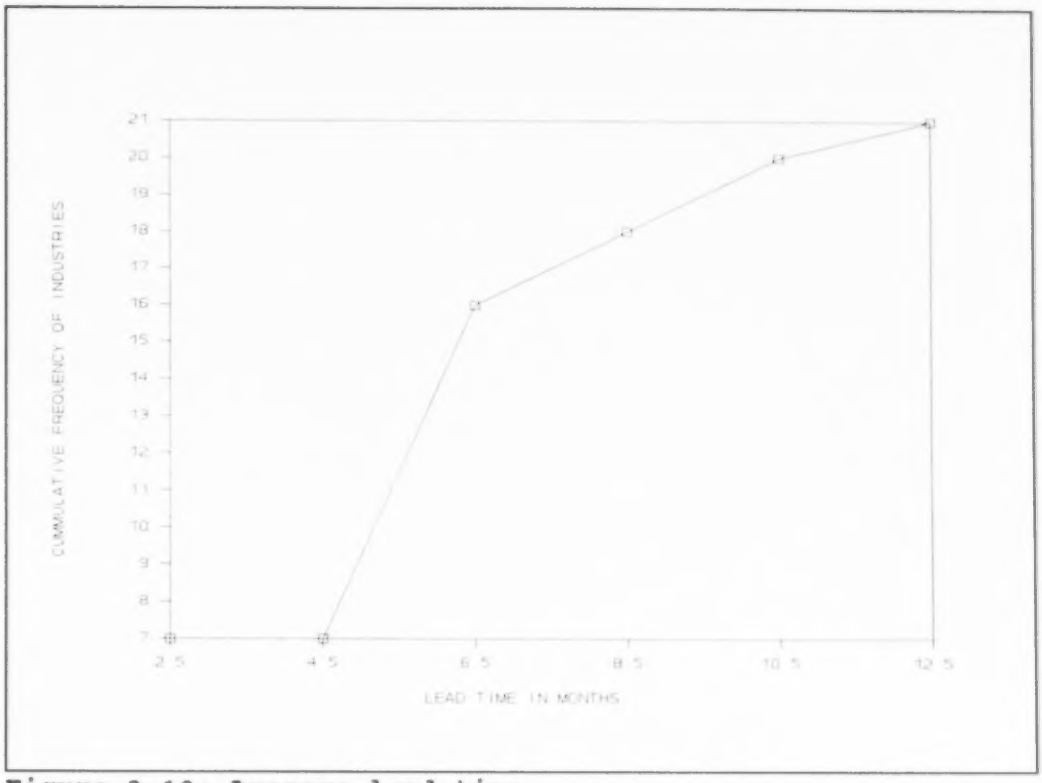


Figure 3-10: Average lead time

Q29. Do you think that something should be done to improve the existing ordering system? Please comment.

The maintenance managers suggested that the present ordering system needs some changes. Bank procedures for acquiring foreign exchange, being one of the concerns. Others are related to bureaucracy within the country. Their comments are summarized as following:

(a) An improvement of the ordering system is within the scope of Government policy.

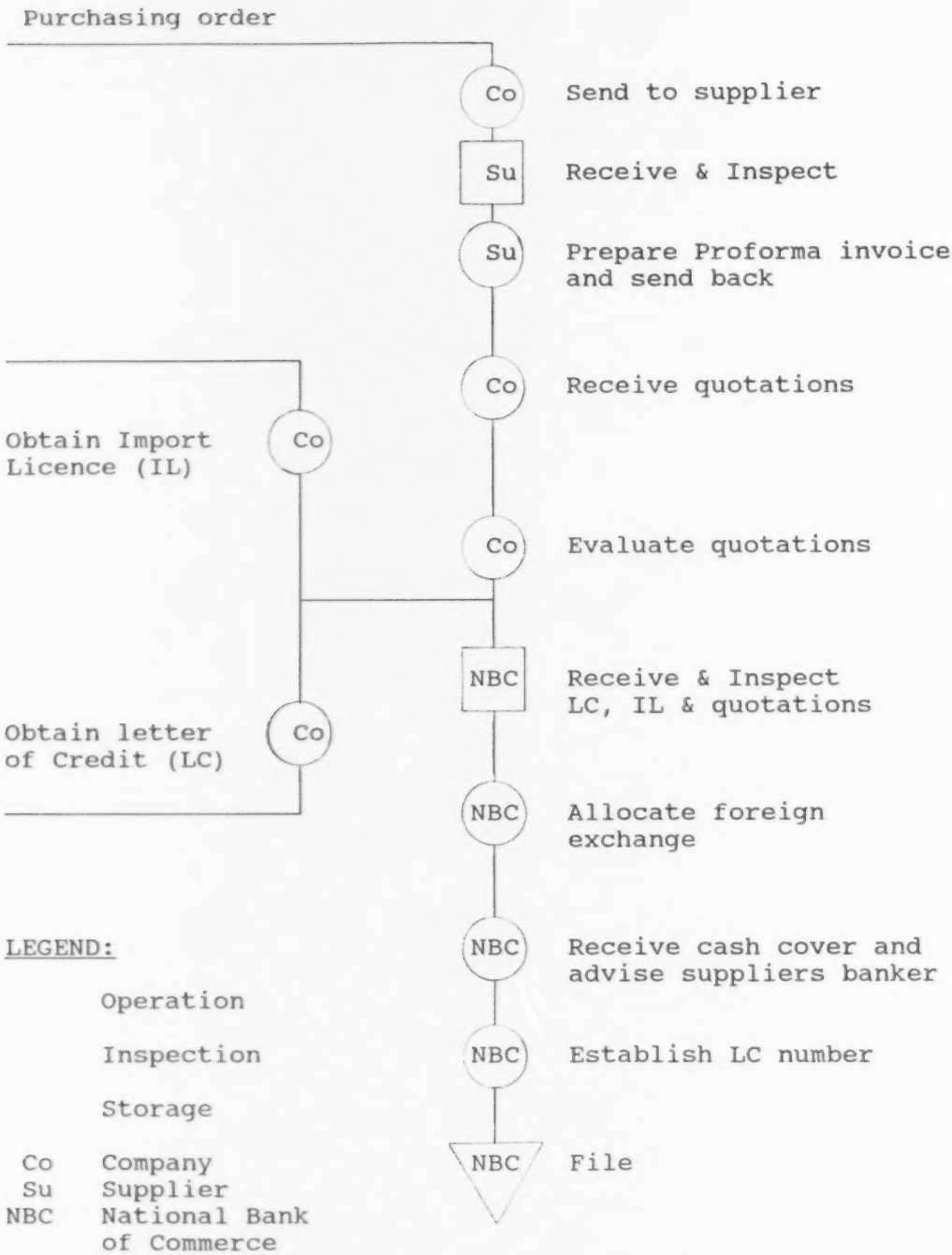


Figure 3-9(a): Bank procedures for obtaining foreign exchange

DURATION: 4 MONTHS

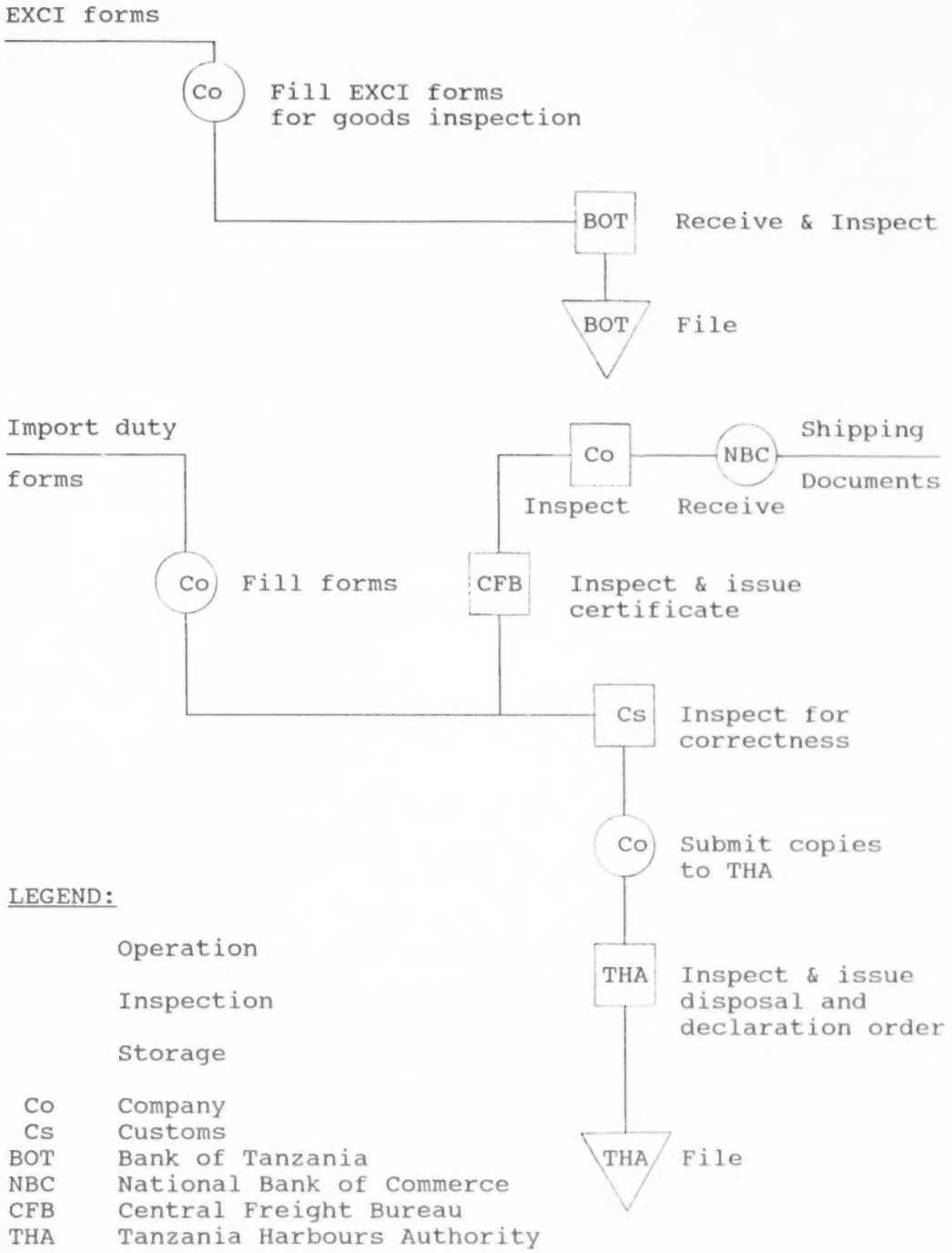
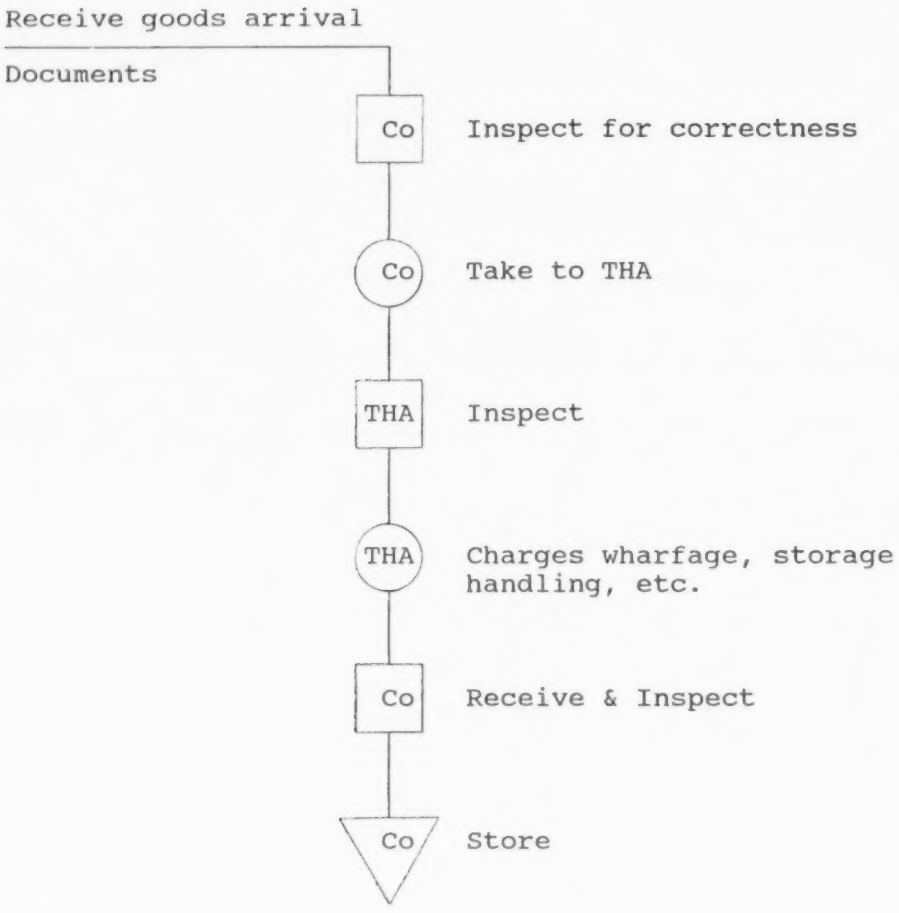


Figure 3-9(b): Spare parts inspection and customs procedures

DURATION: 1 MONTH



LEGEND:

Operation

Inspection

Storage

Co Company

THA Tanzania Harbours Authority

Figure 3-9(c): Spare parts clearance

DURATION: 3 MONTHS

(b) Reduce bureaucracy and paper work both in the bank and the customs.

(c) External accounts should be more liberalized.

(d) Local banks should assist industries getting foreign exchange, to establish letters of credit and order the items immediately. The industries would then, pay slowly before the items are delivered.

(e) Since the ordering system depends largely on the availability of foreign exchange from the federal bank, relevant authorities should look into bank procedures, and shorten them. This will shorten the ordering system as well.

(f) The current ordering system is quite inefficient. Therefore, it needs to be streamlined in order to increase its efficiency.

(g) The treasury should improve its services. Bearing in mind that in doing so it is not serving a particular industry only but also the nation.

(h) Once the efficiency in securing funds is attained, the other formalities could also be carried out faster.

(i) The introduction of an Open General Licence (OGL) system has enabled many companies to use their external accounts for purchasing goods from abroad, without much trouble. It is quicker to process, and more convenient than depending on the federal bank for acquiring funds. Industries should be encouraged to export more goods, and the Government should assist them, by creating favourable business conditions.

(j) The system could be shortened, by either combining or omitting some of the procedures.

(k) Reduce bureaucracy in bank approval.

(l) Nothing can be done to improve the existing ordering system, because there are so many people (parties) involved in making decision.

(m) The problem is within the scope of availability of funds, and the supplier sometimes takes too long to supply.

(n) Establishing a computerized system for purchasing and inventory control.

(o) The national bank of commerce should be given more powers for establishment of letters of credit instead of receiving directives from the bank of Tanzania.

Q30. Do you have other sources of foreign exchange other than the federal bank?

Yes No If Yes, please specify

See Tables 3-24, 3-25, Figures 3-11 and 3-12.

Table 3-24: INDUSTRIES DEPEND ON FEDERAL BANK

Do you have other sources of foreign exchange than the federal bank?	Percentage of replies
1. Yes	86
2. No	14

Table 3-25: OTHER SOURCES OF FOREIGN EXCHANGE

Sources of foreign exchange	Percentage of replies
1. External account	54
2. Others (Import support, grants, aid, etc.)	83

The donor agencies mentioned are such as SIDA, FINIDA, NORAD, DANIDA, JICA, EEC, GTZ, etc.

Q31. What types of welding processes do you employ in your workshop? Please specify; e.g. MIG, GMAW, TIG, etc.

See Table 3-26 and Figure 3-13.

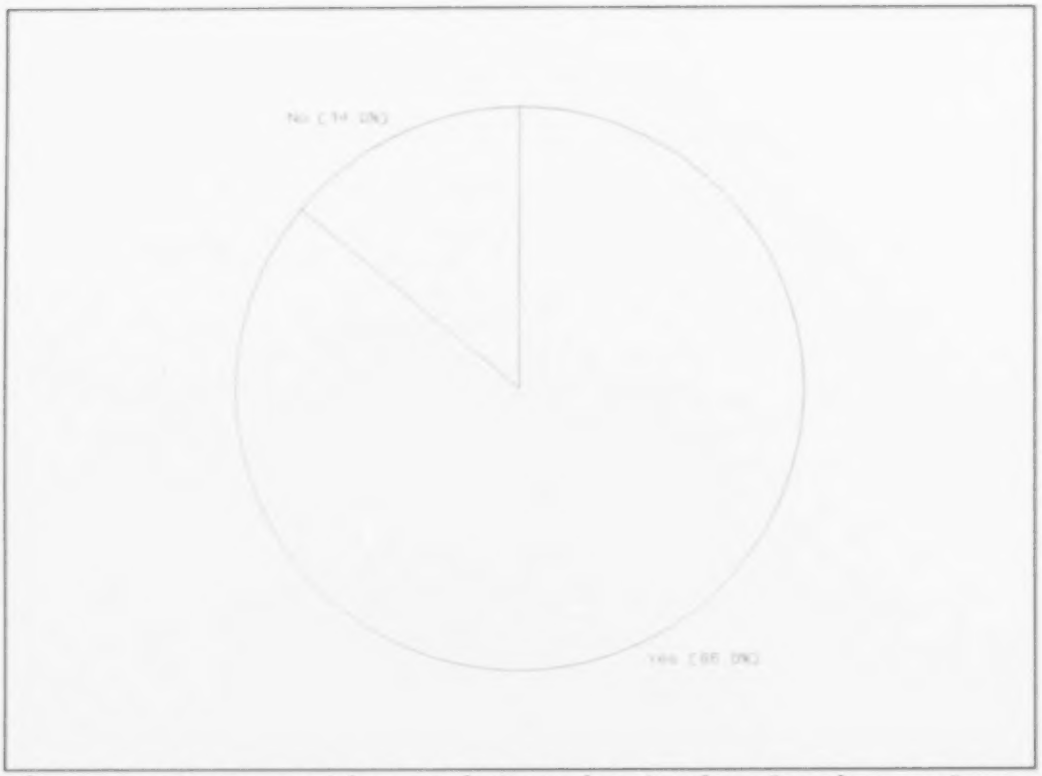


Figure 3-11: Proportion of industries having foreign exchange source other than the federal bank

Table 3-26: TYPES OF WELDING PROCESSES

Welding process	Percentage of replies
A). Oxy-acetylene gas welding	100
B). Arc welding (Stick welding)	100
C). TIG	22
D). MIG	13
E). Metal spray	9

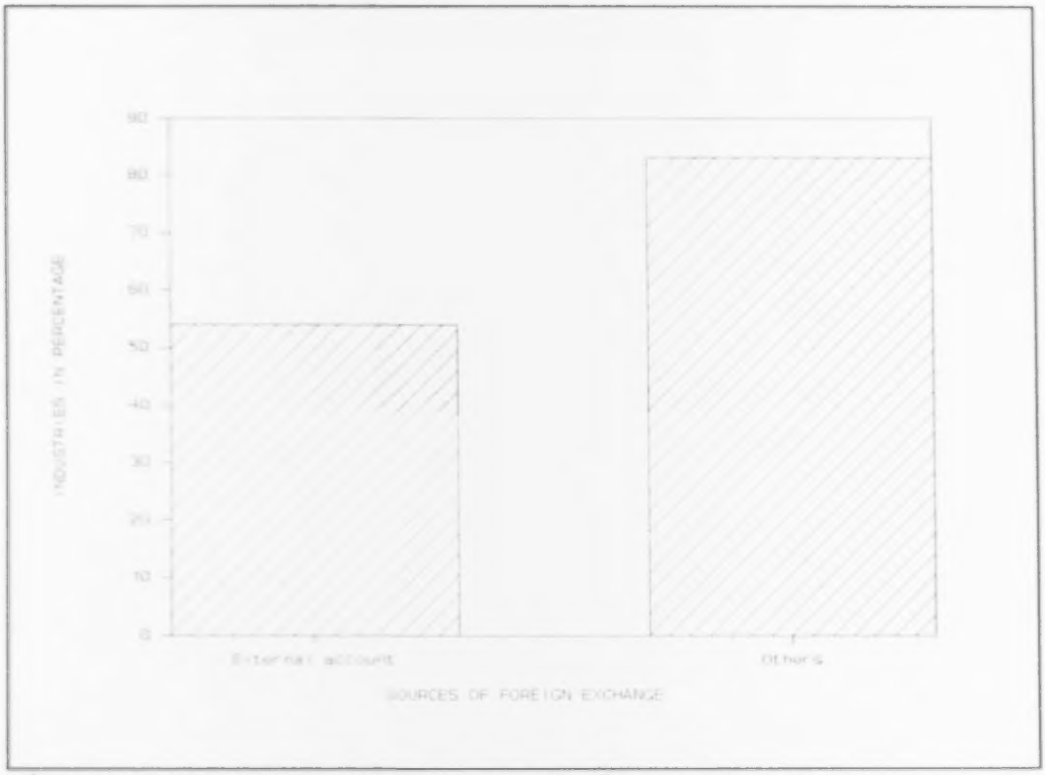


Figure 3-12: Other sources of foreign exchange

Q32. What type and model of machine tools and equipment, do you have in your workshop?

TYPE OF MACHINE OR EQUIPMENT e.g.	PROGRAMMING	AUTO. TOOL ADJUSTMENT	EXTERNAL DATA I/O	SWING (MM)
1. Hitec-Turn	Fanuc 2 axes, contouring	Yes	No	450
2. HC400-40 Horizontal machining center	Fanuc UM-F 3 axes (x,y,z),	Yes	Yes	NA

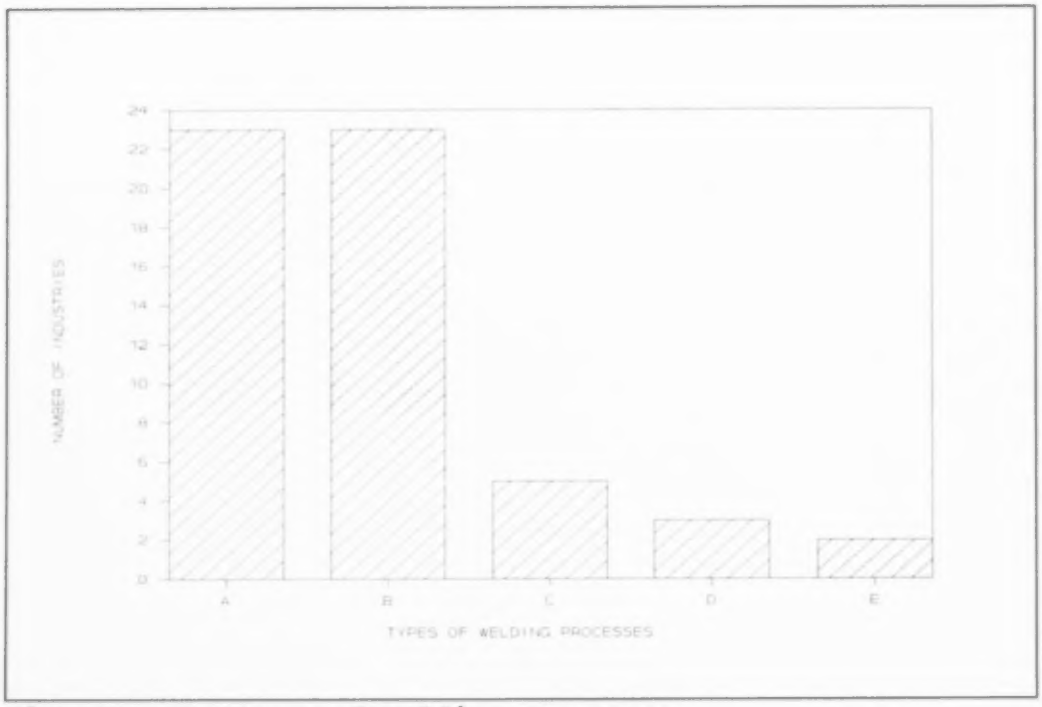


Figure 3-13: Types of welding processes

Table 3-27: MACHINE TOOLS AND EQUIPMENT INVENTORY

Type/Model	Industries Which have
a). NC/CNC Machine Tool	None
b). Conventional Centre Lathe	21
c). Universal Milling Machine	16
d). Surface Grinder	14
e). Pillar Drill Machine	16
f). Shaping Machine	16
g). Boring Machine	5
h). Heat Treatment Facility	5
i). Welding Equipment (Arc Welding)	25
j). Spark Erosion Machine	1

Q33. Please give a summary of your technical personnel in the maintenance department:

QUALIFICATION	NUMBER OF PERSONS Required	Available
Graduate Engineers.....		
Diploma holder Engineers.....		
Technicians.....		
Artisans.....		
Others (specify).....		

The results are summarized in Tables 3-28, 3-29 and Figure 3-14:

Table 3-28: MAINTENANCE STAFF AS A PERCENTAGE OF ALL EMPLOYEES

Maintenance Personnel as a percentage of all Employees	Percentage of replies
3 - 10%	65
11 - 18%	20
19 - 26%	5
27 - 34%	5
35 - 42%	0
43 - 50%	5

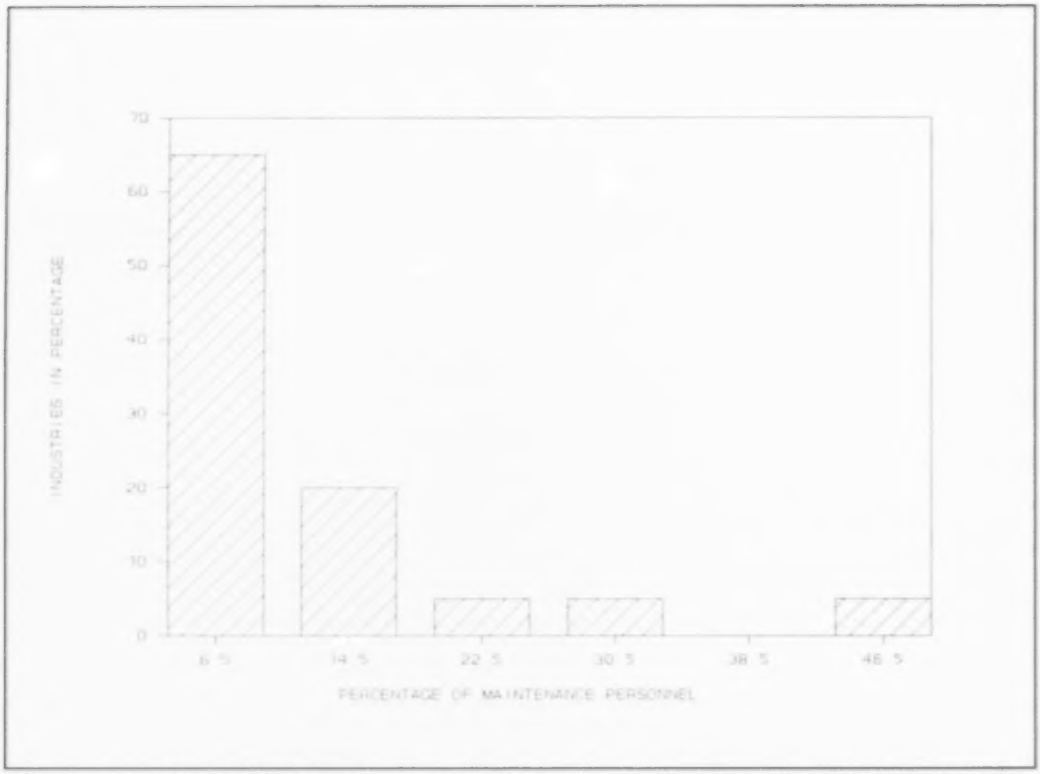


Figure 3-14: Maintenance staff as percentage of all employees

Q34. How much do you spend annually on spare parts?

Thirty eight percent of the companies that responded, were not able to give answers. Two of them indicated that they do not have proper data. However, the rest of the companies gave their annual spare parts expenditures in terms of Tanzanian currency (Tsh.). See Table 3-30 and Figure 3-15.

Table 3-29: SHORTAGE OF MAINTENANCE PERSONNEL

Qualification	Companies which have shortage of					
	more than 3	3	2	1	0	Total
Graduate engineer	1	2	4	6	6	19
Diploma holder engineer	0	1	4	4	9	16
Technician	7	0	4	1	6	18
Artisan	9	2	1	0	6	18
Attendant	1	0	0	0	2	3

Table 3-30: ANNUAL SPARE PARTS EXPENDITURE

Expenditure (million Tsh.)	Number of companies that replied
3 - 13	5
14 - 24	3
25 - 35	1
36 - 46	1
47 - 57	2
58 - 68	0
69 - 79	0
80 - 90	1

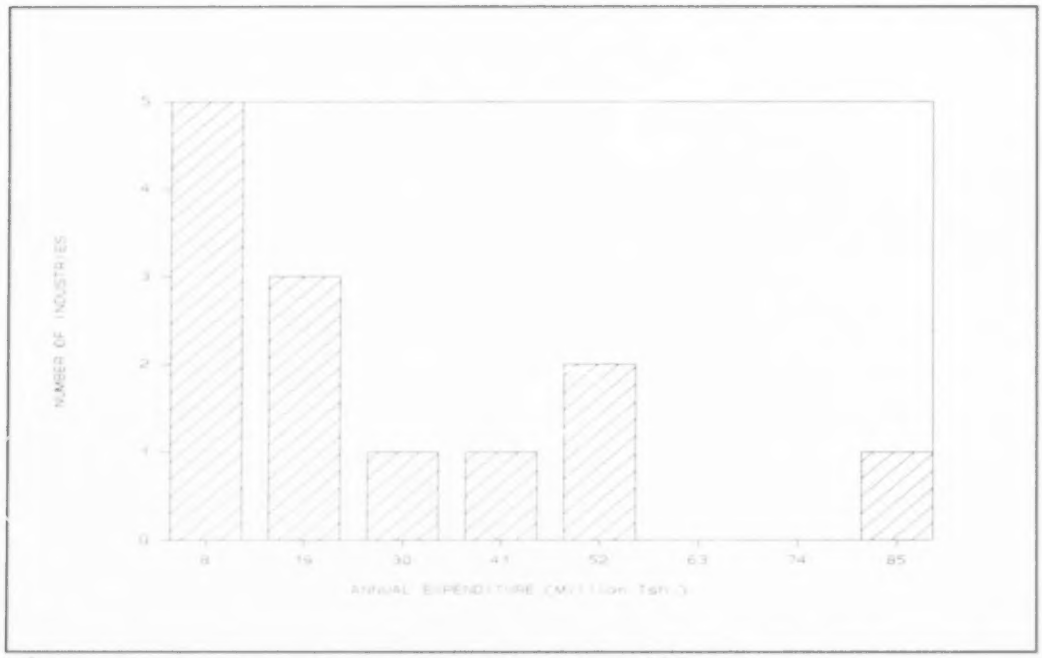


Figure 3-15: Annual spare parts expenditure

Q35. Total investment in equipment?

Fifty percent of the companies that responded gave figures of investment in their equipment, while the remaining 50 percent did not. The investments reported, range from 3.2 to 800 million Tanzanian shillings. See Table 3-31.

Q36. What percentage of your inventory is lost?

Twenty nine percent of the companies that responded did not give data, while 71 percent gave their data. See Table 3-32 and Figure 3-16. The losses were due to reasons such as rehabilitation and obsolescence of machines and equipment.

Table 3-31: INDUSTRIAL INVESTMENT IN MACHINERY AND EQUIPMENT

Total investment (million Tsh.)	Industries which have:				
	Footwear	Engineering	Textiles	Wood processing	Food & beverage
3 - 103		4			1
104 - 204		2			
205 - 305					1
306 - 406		1	1		
407 - 507				1	
508 - 608					
609 - 709					
800 - 900	1				

Table 3-32: INVENTORY LOST

Percentage of inventory lost	Industries responded
0 - 4	10
5 - 9	3
10 - 14	2
15 - 19	0
20 - 24	1
25 - 29	0
30 - 34	0
35 - 39	1

Q37. Do you have trained storekeeping personnel? Yes No

Table 3-33: INDUSTRIES WITH TRAINED STOREKEEPING PERSONNEL

Opinion	Percentage of replies
Yes	38
No	62

Q38. Do you think that developing countries should acquire high technologies in manufacturing?

Twenty two out of twenty six companies agreed to the opinion that developing countries should look for high technologies in manufacturing. See Table 3-34 and Figure 3-17.

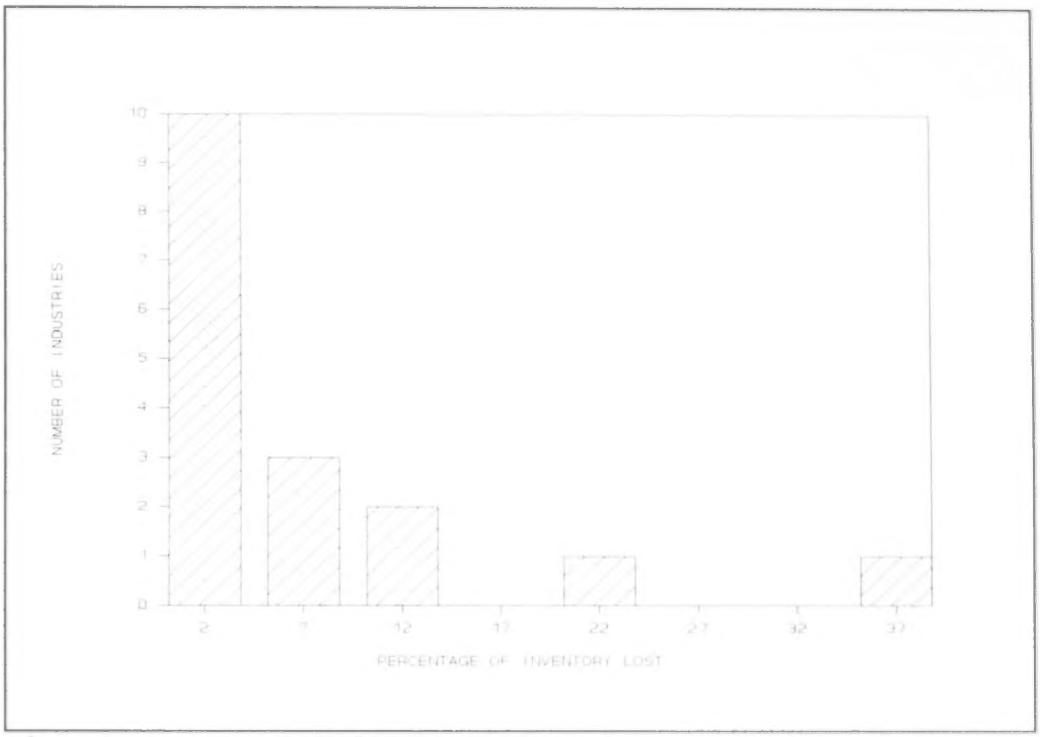


Figure 3-16: Annual inventory lost

Table 3-34: OPINION ON ACQUISITION OF HIGH TECHNOLOGY

Opinion	Percentage of replies
Strongly agree	26
Agree	59
Least agree	12
Disagree	3

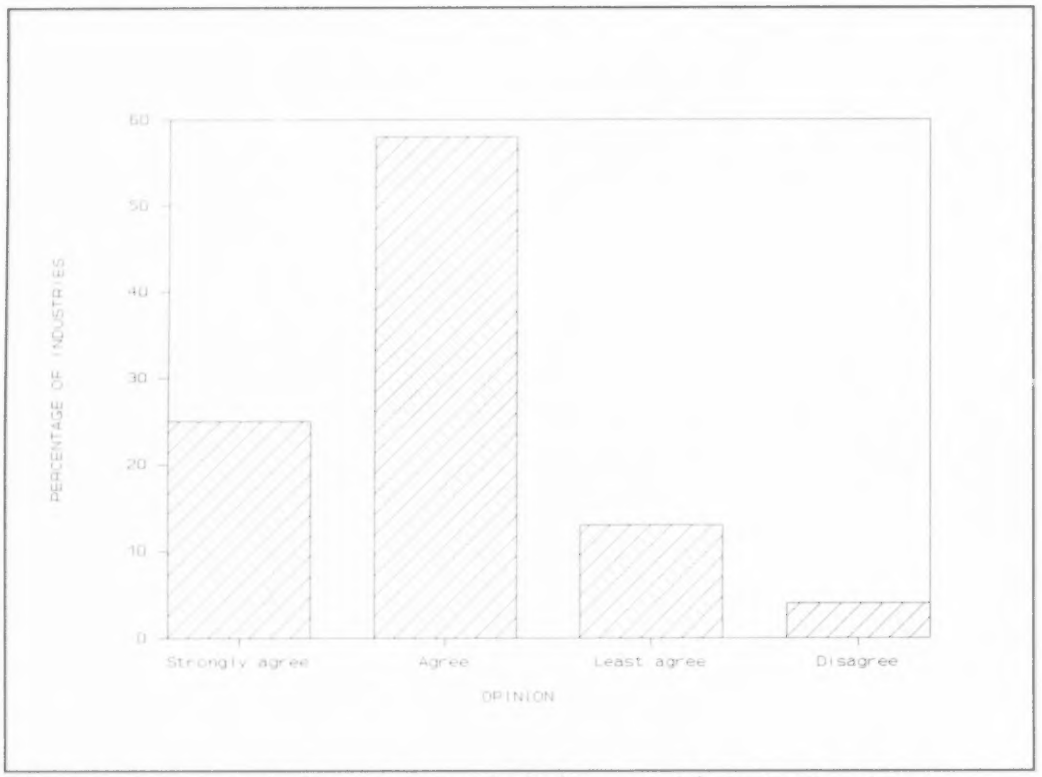


Figure 3-17: Opinion on acquisition of high technology

Q39. Will the availability of spare parts and tools, hence improved maintenance systems, help to improve productivity? Yes No

Twenty six companies indicated that the availability of spare parts and tools would improve their maintenance systems and hence, their productivity. See Table 3-35.

Table 3-35: OPINION ON FACTORS CONTRIBUTING TO PRODUCTIVITY

Opinion	Percentage of replies
Yes	100
No	0

Q40. Any other relevant comments.

Forty two percent of the maintenance managers interviewed, commented as following:

(a) When we contemplate technology transfer, we should first establish the base, i.e. primary industries, such as iron and steel smelters, metal processing industries. Then we can think of establishing the right type of technology transfer. Otherwise, technology transfer is likely not to be successful.

(b) Movements of technical personnel from one industry to another, looking for better working conditions, create instability of skilled personnel. This affects the performance of each workshop. For this matter, managements should look into better motivation systems in order to keep these people inside their companies.

(c) In developing countries, such as Tanzania, apart from maintaining proper inventory of spare parts, modern

reconditioning techniques can also be an economical approach in improving the availability of spare parts.

(d) Whenever purchasing machinery from abroad, industries should insist on new equipment.

(e) Tanzania's industries should insist on having working drawings from machinery manufacturers so that some spare parts may be locally manufactured.

(f) Since the depreciation period in the developing countries is longer than in the developed countries, machinery suppliers should be contracted to supply spare parts for longer periods.

(g) Proper training of personnel responsible for operation and servicing of machines, should be emphasized.

(h) Customarily, spare parts for most industrial machines and equipment in Tanzania are purchased whenever a breakdown occurs. This causes production stoppages for quite some time; resulting in production losses. Introduction of a preventive maintenance system, would minimize this problem. This would be possible if maintenance departments are strengthened by employing advanced equipment and qualified personnel.

(i) Computer technology is required for data storage and records.

(j) The process of acquiring high technology in the country, should be implemented step-by-step.

(k) Due to a lack of maintenance workshops in some industries, there are delays in maintenance, and hence prolonged down time. This situation could be improved by establishing maintenance workshops, where some spare parts could be manufactured or reconditioned, and subcontract only those spare parts which cannot be manufactured in the workshops.

(l) Industries should be encouraged to utilize local industrial research institutes, such as Industrial Production Innovations (IPI) for problems related to the manufacture and development of spare parts, tools and equipment. This will help to reduce dependency on imported spares.

j) The companies should be encouraged by the Government to develop standard components, firstly, and thereafter invest in spare parts for specialized industries.

4.0 Analysis of Survey Data:

The survey collected opinions of maintenance managers because in most factories in Tanzania hard data is lacking in anything except target and production. For the same reasons, Mjema [53] surveyed a number of industries in Tanzania.

In Tanzania's industries, the term "target" is used to specify the planned production output. This is usually set by a government appointed Central Planning Committee (CPC). For a medium or small firm the committee may be within the firm (usually the general manager and other top management personnel). These committee members are nominated by the general manager depending on their involvement with production.

Each firm determines the amount of product to be produced for a certain period of time. The usual period is one year and the production is monitored at short intervals. Since items such as pay incentives, raw materials supplies, and bank credits are all linked to the target; output figures are available because they are required by the financial institutions. However, internal accounts such as maintenance records are usually not kept.

It seems that maintenance managers are relying on directions from the top management (usually the general manager) and very little effort is made in planning their activities. This informal process, usually records little data. Information is passed down verbally or using a memorandum. Each industry may have inherited a certain record system, but the problem is that no efforts are made to enforce the system. The problem of availability of data is varied: most private firms generally keep more data than the government owned firms (parastatals).

The survey data shows that the capacity utilization is between 48 to 58 percent (Table 3-5). Compared to Canadian industrial utilization, it is very low. For example in Canada the capacity utilization in manufacturing industry in 1985 was 78.1 percent [85]. This Tanzanian capacity utilization is higher compared to reported 1988 utilization [15,62]. However, the data should be taken with some cautions because their sources are different. The 1988 capacity utilization data was reported by the government and it is assumed that all industries were involved in the survey, but the 1990 data involved only 5 percent of operational Tanzania's industries.

Other possible causes of high capacity utilization from the survey are: the Economic Recovery Programme (ERP) [63], and

a possibility that the data was overstated by the maintenance managers. The ERP began in 1986 after agreement with the International Monetary Fund (IMF), and the money borrowed was used to pay for industrial inputs including spare parts and raw materials. Due to lack of adequate data in many firms, the data may have been based on the maintenance manager's opinions.

There maybe an error in the determination of capacity utilization. The usual method is to compare the actual production to installed capacity (machine capacity). But, there is a possibility that other industries compare the actual production to production targets. Many industries do not have data, therefore, it is unlikely that the installed capacity is known. Thus, many companies may have reported the utilization derived from their targets.

Importance of Spare Parts:

Tanzania's industries suffer a capacity under-utilization, and one of the causes of this condition is the unavailability of spare parts required to maintain machinery and equipment [98]. A United Nations Industrial Development Organization (UNIDO) report of 1969 [92], indicates that there is a general consensus that the lack of spare parts is a handicap in almost all developing countries.

The spare parts problem was ranked third in the list of problems that cause target shortfalls (Table 3-6). Eleven out of twenty six companies surveyed acknowledged a problem of spare parts. Spare parts are required in order to repair the broken down machinery. Thirteen out of twenty six companies indicated that they are experiencing machine breakdown.

For problems facing workshop operations (Table 3-7), lack of spare parts was ranked second to age of machinery and equipment. Seventy nine percent of the industries admitted that they have a problem of availability of spare parts for repairing their machinery. The reported high rate of machine breakdown may support a shortage of spare parts. About 75 percent of the industries acknowledged that they are experiencing a high rate of machine breakdowns (see Table 3-7).

From the standpoint of the industries, lack of spare parts was ranked the worst among the problems facing them (Table 3-8). The shortage of spare parts is aggravated by the fact that only 40 percent of spare parts requirement can be obtained locally (Table 3-13 and Figure 3-6). These spare parts are either available in local hardware stores or manufactured, but often they require raw materials, which are imported. The percentage of spare parts obtained

locally, may even be lower than reported. Most spare parts are imported into the country, but due to the state's meagre foreign exchange reserves, importation is difficult. Table 3-24 shows that 86 percent of responding companies depend on the federal bank for foreign exchange.

Problems With Spare Parts:

Tables 3-9 and 3-17 summarize spare parts problems. Lack of raw materials such as steels is the top ranked. Other problems according to their importance are as follows:

- lack of technology
- lack of working tools
- delay in supply of spare parts and raw materials (long ordering procedures)
- lack of technical skills
- inadequate machine tools
- inaccuracy of machine tools
- lack of specialized equipment
- age of machinery
- lack of drawings and low quality
- lack of heat treatment facilities and measuring instruments
- frequent machine breakdown
- lack of modern machine tools and equipment

Other causes reported by a few industries are:

- provision of foreign currency
- lack of raw materials specifications and standardization
- difficult sources and communication
- different dimension versions
- obsolescence of machines
- lack of funds

These results suggest that the availability of industrial spare parts in Tanzania's industries is a major problem and reasons and causes for spare parts problems are analyzed in the following sections of Chapter 4.

4.1 Availability of Raw Materials:

Lack of raw materials such as alloy steels, carbon steels, fibre, plastics, cast iron, copper and rubber, required for manufacturing of various spare parts in the country is a serious problem. Thirteen out of twenty six companies admitted that unavailability of some raw materials deterred effective spare parts manufacturing operations in their workshops (see Table 3-17). Table 3-7 shows that 79 percent of responding industries indicated that a problem of availability of raw materials affects their operations. This high response includes all raw materials, and does not conflict with the 50 percent as reported previously. Some of the materials are sometimes available locally, and can be

purchased by the local currency. But, in most cases they have to be imported from abroad and the country does not have adequate foreign currency. Table 3-18 shows some raw materials and their sources.

Tanzania does not have some of the technologies and facilities required for production of some raw materials. For example, the national annual consumption of steel is 500,000 metric tons, the majority of which is imported [15].

Another problem which aggravates the problem of raw materials is a series of devaluations of the local currency. Since 1988 the currency has been devaluated by about 60 percent compared to the United States dollar. This has lowered the purchasing power of the local currency, at the same time the earnings have not increased favourably. Thus, prices of raw materials have substantially increased, and many companies find it difficult to purchase them.

4.2 Lack of Modern Technology and Equipment:

According to Table 3-27, all respondents indicated that their workshops are equipped with conventional machine tools. The machines utilize old technology, dominated by manual operations. Only one workshop has spark erosion machines which can be programmed to work without human presence. In Table 3-17 a few companies indicated that they

lack specialized equipment, modern machine tools and technology. These responses mean that the companies don't have those facilities within their own workshops, but they are available in other companies. It seems that generally the availability of equipment is not a major problem.

Some technologies required to manufacture some spare parts locally are unavailable. Examples of spare parts are electrical components, bearings, chains, belts, cams and associated followers, seals and o-rings, pumps and impellers, pistons and rings, axles, hydraulic and pneumatic parts, mould and springs. The technologies involved in the manufacturing of the above parts are die forging, casting, moulding, cutting processes by specialized machines, welding and heat treatment. The availability of these spare parts could be improved if people would make them locally rather than importing them. This is because of the lack of foreign exchange.

The maintenance managers feel that if the technologies mentioned above are imported into the country, they could manufacture most of the spare parts required locally. However, it should not be expected that Tanzania will ever be self-sufficient, because it may be very expensive to establish these technologies. Seventy seven percent of the

industries surveyed agreed to the opinion on import of technology (see Table 3-22).

4.3 Lack of Tools, Drawings and Measuring Equipment:

Most of Tanzania's industries are equipped with small, multi-purpose workshops where spare parts could be reclaimed or manufactured. The tendency, nowadays, is to attempt to manufacture or recondition as many spares as possible. However, most of the spare parts lack engineering drawings to show their dimensions, material from which they were made and heat treatment. This is very serious when a new spare part needs to be manufactured. The normal practices are to re-trace the dimensions from the worn out part, add allowances to the worn out areas and finally to manufacture it. After manufacturing, the spare part is fitted where it belongs. If it fits properly, then the dimensions have been established correctly, otherwise adjustments may be necessary. It is a tedious and time consuming job.
Lack of cutting tools such as high speed steel bits, carbide tipped tools, milling cutters, twist drills, broachers, diamond dressers, and other specialized tools and measuring equipment was reported by some companies. All are imported into the country either by the companies or private vendors.

Some companies include tools in their orders of raw materials, but most of them rely on local vendors. The

prices in the local market are very high and some companies find it difficult to provide sufficient tools to their workers.

Another problem which affects availability of working tools is ineffective workshop management. Tools are often stolen by workers and resold to other workshops or stores so as to subsidize their low income.

Table 3-17 shows that only three companies indicated that they lack measuring and testing equipment such as vernier callipers, micrometre gauges, dial gauges, thread gauges, hardness testers and depth gauges. This low response rate indicates that it is not a problem but, it does frustrate workshop operators. This equipment, if used and kept properly, will last for a long time. Some workshops do not have sufficient measuring equipment.

An example from the author's working experience in CMB Packaging Company (the former Metalbox company) illustrates the problem of availability of sufficient measuring equipment. It is common to find more than four workers sharing one vernier calliper, or one dial gauge for a workshop of more than fifteen workers. In such cases one is often idle because the measuring equipment is being used by

someone else. This situation affects the utilization of the facilities and also lowers worker's morale.

4.4 Skilled Technical Personnel:

About 50 percent of the industries indicated that inexperience of technical personnel hampers their engineering work (see Table 3-7). The possible cause of a lack of skilled personnel is a lack of an effective system of training. The system of training in Tanzania's industries does not provide sufficient practical training to balance the formal training at colleges. Once the student finishes her/his technical studies, she/he is posted to a job without any post practical training in the relevant area of discipline in order to be familiarized with her/his novel working environment.

Some of the respondents suggested that managements should provide a favourable learning environment to technical personnel in their organisations by providing necessary material and moral support. For example, a young engineer, fresh from college would be assigned a post which requires specialised technical ability without training. This problem has also been addressed by S.I. Kisimbo (TISCO), in his paper, 'Training of engineers in Tanzania'. The paper says:

> **".. Fresh graduates fill responsible posts immediately after they leave the university. Such responsibilities usually require them to make important decisions related to economics, management, planning in addition to the tasks within their broad area of discipline without any post graduate professional experience". [106].**

Hence, if post practical training is not included in the training program of technical personnel, and availability of machines and working tools is not improved, this problem of lack of skills to technical personnel will persist.

4.5 Systems of Ordering and Provision of Foreign Exchange:

The author refers to the system of ordering spare parts and tools from abroad. The industries have indicated that the procedures of ordering spare parts from abroad are cumbersome because of the bureaucracy involved; each industry has to apply for an import licence before proceeding to securing foreign currency from the federal bank, and placing the order with the supplier abroad.

Basically, there are two sources of foreign currency available to the industries -- the federal bank and foreign donors in the form of "grants". If the industry depends on the bank for acquiring foreign currency, the processes could be longer than depending on grants. Not only does it take a longer time, but also one is not sure of getting the currency, because it will depend on the bank's situation.

If there is sufficient currency, then there is no problem, but sometimes the bank cannot meet its customer's demands. The bank must ration according to national priorities.

Refer to Figures 3-9(a), (b) and (c), the import procedures based on the bank as the source of foreign currency are as follows;

1). Obtain quotations from the suppliers

2). Obtain import licence

3). Obtain letter of credit (LC) from the central bank. The bank requires cash coverage in local currency. Normally full payment.

4). Fill forms for inspection and submit them to the bank of Tanzania (BOT)

5). Shipping documents are received by the vendor through his banker.

6). Fill the import or free duty entry

7). Submit (6) to the customs with a certificate from the central freight bureau which certifies the correctness of the freight.

8). Submit the above copies with disposal and declaration order to Tanzania harbours authority which charges for wharfage, storage and handling expenses.

9). Finally you will receive a bill of lading, invoice, packaging list and other relevant documents required to collect your goods.

The ordering system takes an average of 8 months before putting the spare parts in stock. Processes (1) to (3) are all necessary for acquiring some foreign currency from the bank. The rest are just formalities which can be reviewed for improvements. Some Tanzanian maintenance managers feel that the bureaucracy within the country should be reduced in order to speed up the processes. Ideas expressed included combining or omitting some of the procedures, and making people more responsible and productive!

4.5.1 Lead times:

The lead times for ordering spare parts from abroad are quite long. For example, the industrialists have indicated that the lead times are 2 to 12 months. The time will depend on the source of foreign currency, the country where the spare parts are to be ordered and the company itself.

As the author mentioned in Section 4-5, the source of foreign exchange contributes to the length of ordering processes. Those companies which operate foreign accounts have the advantage in that they are not required to apply for funds from the federal bank of Tanzania for approval. They only require an import licence and communication with the supplier and the external banker. These processes are quite short.

The problem of long lead times affects the availability of spare parts.

4.6 Age and Type of Machinery and Equipment:

Fifty percent of the responding industries indicated that age of machinery and equipment was strongly related to the high rate of spare parts consumption: 38 percent agreed, 12 percent disagreed (see Table 3-11). These responses include all machines and don't refer to spare parts manufacturing machines only. Table 3-17, four companies indicated that they have old aged spare parts manufacturing machines. The above responses don't conflict, rather they were derived from two machine categories.

The statement: age of machinery and equipment is related to high rate of spare parts consumption is true if it is taken at face value. The fact is that when a machine becomes old, parts deteriorate either by wearing out or aging, and in order to maintain it, a lot of spare parts are required. Unfortunately, it may be difficult to diagnose and discover all parts which need to be replaced. Furthermore, due to an inadequate preventive maintenance program in many industries [53], machines break down is unpredicted.

The problem of poor maintenance practices plays a part in the high rate of spare parts consumption. For example, if a

bearing is over-tensioned, it will wear out faster than was anticipated.
According to Kishimbo's paper, quite a large number of Tanzania's industries have aged machinery, and much of it was purchased second hand [106].

Tanzanian industries have a wide variety of machinery and equipment. These facilities may be obtained from different manufacturers and different countries. For example, CMB packaging company has more than four machine brands from different manufacturers and countries. The countries are the United Kingdom, Sweden, West Germany and Italy. Each time spares are being replenished, there will be four set-up costs for four separate orders. Also, each stock will require a certain location in the shelves. This will add extra costs.

This situation is common throughout the country. It may be partly attributed to foreign donors who predetermine the machinery supplier without advising the recipient of the aid. Other times it is due to the government policy of accepting the lowest bid. For example, in the transport industry, there are cars from Japan, United Kingdom, India, France, China, Russia and Hungary, just to mention a few. From Japan itself, there are more than ten brands of cars imported into the country. This situation is not unique to

Tanzania but where possible a more thorough job of screening bids for new and used equipment entering the country is highly desirable.

4.7 Machine Breakdown:

Thirteen out of twenty six companies indicated that a problem of frequent machine breakdown is one of the causes for targets shortfall (see Table 3-6). Machines are often not available. The main cause of breakdown is attributed to inadequate maintenance work [91]. Not all industries in Tanzania have well established maintenance departments. According to Mjema [53], few Tanzanian Industries have established effective maintenance and repair practices (See Table 4-1). This suggests that maintenance records such as spare parts, costs and repair performed are not available, and often spare parts required may not be determined.

A problem of management of various industries in Tanzania is that they focus more on production than maintenance of machinery. The problem was also noted by Mjema:

> **".. top managers emphasize production and fail to realize that high productivity is highly correlated with good maintenance management" [53].**

4.8 Different Dimension Scales, Standardization and Quality:

As mentioned in section 4.6, Tanzania's industries have

diversified machinery and equipment from different manufacturers and countries, and since each country adapts to its own dimension scale, there is little interchangeability of parts.

Table 4-1: Types of Maintenance

Types of Maintenance Mentioned	Percentage of Replies
1. Breakdown Maintenance ..... (Unplanned breakdown)	90
2. Preventive Maintenance	50
3. Predictive Maintenance	5

Source : E.A.M. Mjema's Report, "Study of Industrial Maintenance in Tanzania, University of Alberta, Edmonton, 1990.

There are two main scales, the metric and imperial, used to dimension the spare parts. Both systems can be used effectively, but the problem is the danger of mixing spare parts of the two systems. The problem is even more dangerous when one is trying to establish dimensions for a worn out spare part without knowing the original dimension scale used.

Though some companies have already demonstrated their determination to manufacture industrial spare parts, still

lack of standardization deters effective competition. In most cases, spare parts manufactured do not meet quality requirements.

Standardization should start with raw material specification; this will indicate material composition, strength [tensile strength, yield strength, etc], heat treatment conditions. Not all manufacturers include all the above specifications, despite it being necessary to know the qualities of a particular material before using it.

In Tanzania, this problem of material specification is common. The questionnaires sent to the industries revealed that some steels imported from countries in Asia enter without important specifications, and in order for an industry to use them they have to conduct a composition analysis. This costs time and money to the industry. It is not clear why such steels without specifications are accepted into the country, but possibly they are provided as aid. Unfavourable aid was also addressed by Mjema [55].

Another problem is nonstandardized technological practices offered by some engineering workshops. For example, welding of a machine part using an unsuitable process or filler material. Often the repairs are not successful or the parts do not last. There is a need for standardization of

technological processes in Tanzanian industries in order to render better technical services to clients and to match the quality of imported spares.

Though some spare parts are designated by manufacturer's part number, they can be procured as standard parts. These spare parts include bearings, bolts and nuts. If these parts are standardized, they can be procured and manufactured easily.

Quality of local spare parts is a problem which results in low sales volume. About 17 percent of the respondents said that they had a spare parts quality problem (see Table 3-9). In order for Tanzanian industries to be competitive in the local market, they must produce spare parts which conform to the reliability standards of the original spares. The same recommendation was addressed at International Labour Organization (ILO) report, "Consultation on the Training of Industrial Manpower". It states that:

> **"The promotion of local spare parts manufacture should be based on a careful and realistic assessment of quality .." [33].**

Therefore, the management of companies should know their clients, and understand their needs and expectations so that they can serve them better.

4.9 Difficult Sources and Communication:

Not all the spare parts required for repair and maintenance of machines and equipment can be obtained from the manufacturers. According to the study conducted in Tanzanian industries, about 17 percent of the respondents showed that they do not obtain spare parts from the machinery manufacturers. They depend on local availability. Mjema [54] indicated that the practice is to manufacture or order when spares are needed. Some companies indicated that only a meagre proportion of the spare parts required are supplied by the manufacturers.

Most industries depend on imported spare parts which are difficult to obtain because of foreign exchange shortages [15]. This situation has forced maintenance Engineers to look for alternative solutions, which utilize the available resources, technologies and facilities in order to make these parts.

At the national level, this problem was also recognized. In 1989, the President of the United Republic of Tanzania, Hon. A. H. Mwinyi, made several visits to various Engineering workshops to discuss with managers the possibility of manufacturing most spare parts which were imported [17]. Out of these discussions, the managers admitted that most of

the parts presently imported could be successfully manufactured locally.

A common reason is because the machines although still in operation, are obsolete and the manufacturers have ceased production and supply of spare parts for the models. Some manufacturers are even out of business. For example, machines supplied by small scale industries from some countries in Asia. This is a problem because manufacturers often do not supply working drawings which can be used for the local reclamation and manufacture of spare parts. Also some spare parts require specialized machinery and technologies which are not available in the country. In many instances, only reconditioning techniques, e.g. welding, are available to reclaim the spare parts and not all spare parts can be reconditioned successfully. For example, rubber parts need to be replaced with new ones.

The problem of not being able to obtain spare parts from the manufacturers may in part be attributed to the fact that many manufacturers would not contract for supplying spare parts during the procurement stage. As a comment to this problem, some maintenance managers indicated that manufacturers should contract to supply spare parts for a longer period.

4.10. Spare Parts Management:

The problem of spare parts supply shortages is partly attributed to unfavourable inventory management [53]. The problem of unfavourable inventory planning and control makes it difficult to carry out maintenance work. It is common to Tanzania's industries to order spare parts in order to repair already broken down machines [54].

The problem of proper inventory management is indicated by most of the industrialists in Tanzania; 62 percent of the respondents indicated that they experience inventory loss, and 38 percent do not have trained store keepers (See Table 4-2). The inventory loss was reported to be caused by either obsolescence, pilferage, deterioration, or major rehabilitation of some machines.

It was difficult for some companies to provide data for inventory loss because they have never kept proper accounts of their stocks. This is a serious problem because one cannot realize how the build up of stocks poses a threat to the health of the business by taking capital from other needed areas.

Even in those companies with trained storekeeping personnel, the availability of spare parts causes troubles that disrupt operations.

Table 4-2: SPARE PARTS INVENTORY PROBLEMS

Description of the Problem	Industries which have
i. Trained Storekeeping personnel	38%
ii. Inventory Loss	62%

4.11 Advertising Products:

About 42 percent of the industries showed that they have problems of selling their spare parts or technical services (see Table 3-7). It was suggested by several maintenance managers to the author that, in part, this is an advertising problem. Very few Tanzanian industries advertise their products or services. Most of them have ignored the importance of advertisement to their undertakings; maybe they view it as a waste of money. This is unfortunate because advertisement is communication between manufacturers and clients about products (new products, prices, customer services, etc.) or technical services they offer.

The advertising media available in the country are such as newspapers, magazines, radio, exhibits and displays at trade shows, and posters. But, none of them are being utilized effectively. If the above advertising media are utilised effectively there will be a better linkage between the industries producing spare parts and their clients; one will

know whom and where to get a certain part or technical service.

4.12 Electricity Shortage:

About 58 percent of the respondents indicated that they had an electricity shortage (see Table 3-7). The problem of electricity shortage could be in a form of frequent power outage or excessive power fluctuations or insufficient power supply. For example, some companies could not install some of their machines because of the power supply.

The power fluctuation has caused damages to some electrical components and also malfunction to some machinery. The fluctuations are believed to be caused by the distribution transformers which are being controlled by the Tanzania Electric Supply Company (TANESCO).

The most frustrating problem in day to day operations, may be power outage. Sometimes TANESCO will inform its clients of the power interruptions but most of the time there is no warning. This has affected planned activities in the industrial shops. For example, heat treatment of spare parts is often interrupted by power outage. When the failure occurs it will take at least one day before the power is restored. For example, when a power outage occurs, one has to communicate with nearby TANESCO office, reporting the incident. TANESCO responds and allocates its engineer

to attend to the fault. It may take about a day or longer before they attend to the job, and the time wasted is a loss to the particular industry itself. In addition to the lengthy service time supplied by TANESCO, the total power supply available is not sufficient to meet the demand. As a result companies often have to shut down machines during peak hour use of electricity.

4.13 Number of Maintenance Personnel:

The number of maintenance personnel compared to total employees in the company were studied in order to assess if the maintenance team is adequate to execute maintenance work effectively.

According to the questionnaires sent to Tanzania's industries, about 65 percent of the respondents showed that they had 3 to 10 percent of maintenance personnel compared with total employees (see Table 3-28 and Figure 3-14). This is below the median of twelve percent of the companies surveyed and may indicate a danger of overworking these people, and possible omission of some maintenance activities. According to the established British maintenance cost indicators, many industries have maintenance staffs ranging from 3 to 8 percent of all employees [103]. This data may suggest that for an underdeveloped country such as Tanzania, one would expect a

higher percentage of maintenance personnel because of old equipment and poor maintenance policies. However, there is no empirical formula which determines the number of maintenance personnel. Further, there is no data to suggest that British standards can be used as a guide for Tanzania.

The maintenance managers interviewed were concerned with the sizes of maintenance departments and qualifications of the personnel. They have indicated that they need more engineers and technicians in order to reshape their maintenance systems.

4.14 Summary:

An availability of industrial spare parts is a major problem in Tanzanian industries. The survey data shows that industries operate at low capacity utilization because of a shortage of raw materials and machine breakdown. These machines break down due to poor maintenance procedures, untrained staff to carry out the maintenance works smoothly and old machinery. Machines do not get repaired quickly due to the following reasons:

- spare parts are not available
- company cannot afford parts (lack of funds)
- tools are not available
- few people know how to maintain machines

Spare parts are not there because of the following reasons:

- industries lack funds (foreign exchange and local currency)
- machines break down so frequently that all parts are used up before another stock arrives
- old, worn, obsolete machines
- a large variety of machines which creates many problems in keeping stocks
- no records (spare parts requirement cannot be accurately determined)

Another problem is that spare parts cannot be obtained quickly because of long lead time (bureaucratic ordering and customs clearance systems) and difficult sources (some suppliers no longer in business).

About 60 percent of spare parts requirements are imported into the country and lack of foreign exchange hampers the importation. The local manufacture of spare parts is facing problems such as availability of proper steels, manufacturing facilities, working tools and testing equipment, appropriate technology and technical skills.

5.0 Spare Parts Problems in Tanzania:

In chapter 4 information gathered from the questionnaire sent to Tanzanian industries was used to briefly discuss problems facing these industries. In this chapter, Tanzanian practices are compared with some of the practices used in a Canadian company. Furthermore, the author will draw on his industrial experience in Tanzania (more than 6 years in different industries) to add insight to the problem evaluation.

5.1 The Design of a Spare Parts Ordering System:

Figures 3-9(a), (b) & (c), show ordering procedures and time involved. The time elapsed from when a purchase order is sent to a supplier abroad to when one receives spare parts is estimated to be eight months. For small parts orders, this is quite a long time. The ordering system can be divided into three sections:

i) submission of the pro forma invoice to the bank to obtain foreign exchange;

ii) inspection of spare parts and customs procedures; and

iii) spare parts clearance.

About 50 percent of the total ordering time is spent on processing for foreign exchange. One has to report several times to the bank asking if his or her request has been processed. This is contrary to procedures in Canadian banks

where small foreign exchange transactions may be processed in a matter of minutes.

The reason for the close control of foreign exchange is the national shortage of foreign exchange. The problem of foreign exchange scarcity in Tanzania is attributable in part to the low volume of exports, the low price of primary product exports in the world market and the high price of imports. The main trend in the country's trade balance during the 1970's was the low growth of exports compared to imports. This is believed to have been caused by a number of factors such as the increases in oil prices during 1974-75 and 1979 and the deterioration in Tanzania's terms of trade [44].

As a result, the Government is controlling importation of goods to ensure the use of the scarce foreign exchange in accordance with national priorities. In a market economy, shortages are indicative of improper pricing [51]. From this perspective, Tanzania's "foreign exchange shortage" can be construed as an "over-valued exchange rate". At official exchange rates, which are strictly regulated in Tanzania, exports are under-valued and imports are under-valued; this result is diametrically opposed to the "self-reliance" objective of the Arusha Declaration. It also means that instead of a market-clearing price for foreign exchange,

there is an excess demand for foreign exchange, so the scarce foreign exchange is allocated by means other than price. The result is lengthy bureaucratic procedures, and a situation that lends itself to development and fostering of corrupt practises.

In the questionnaire analysis (see Chapter 4), some maintenance engineers who were interviewed contended that the lengthy bureaucratic processing involved in securing foreign exchange from banks must be streamlined in order to reduce processing time. Figure 3-9(a) shows that a company has to obtain an import licence (IL) and a letter of credit (LC), before it can apply for foreign exchange. These documents are obtained from the Bank of Tanzania (BOT). Formerly import licensing was a responsibility of the Ministry of Industry and Trade. But later, it was made one of the tools of financial planning and management and thus placed under the BOT.

The BOT has legal authority to manage all foreign exchange. Thus, in 1971, the Government decided to relate the granting of IL's more closely with the availability of foreign exchange and the priority needs of the economy [45]. A problem bothering many importers is the bureaucratic system involving two banks; BOT and the National Bank of Commerce (NBC). In addition to managing foreign exchange, BOT also

has central bank responsibilities, including: issuing currency, acting as banker to the Government and financial institutions and implementing monetary policy. The NBC is the sole commercial bank in Tanzania. Foreign exchange is obtained from the NBC via the BOT. This measure was introduced in response to a growing trade deficit coupled with rapid deterioration of foreign exchange reserves.

In December 1971, the bank introduced the Open General Licence (OGL) facility in order to expedite importation of some goods [45]. The OGL is a list of goods which could be imported without IL (note that foreign exchange from the bank is allocated subjected to IL approval), spare parts being one of them. Others goods on the OGL include medicines and vaccines, live animals, animal semen, seeds, fire engines, fire escapes and tug boats. The OGL allows those industries having sources of foreign exchange other than the BOT to import the authorized goods without acquiring IL's*.

IL's were allocated subject to availability of foreign exchange. For example, during the first half of 1981, only 28.3 percent of total requests were allocated ILs. In the corresponding period of 1982, only 15.2 percent was

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*For spare parts whose value exceed US dollars 500, importers must obtain import licence.

approved. The severe excess demand for spare parts in the early 1980's may be illustrated by the level of IL allocations. During the 1980-1982 period, approval for spare parts imports declined from 9 percent in the first half of 1980 to about 2 percent in the first half of 1982 [45]. The problem of how to make sufficient foreign exchange available is intractable as long as the Government attempts to maintain an over-valued exchange rate.

At present, the Government encourages industries to export their products by allowing them to operate foreign accounts inside or outside the country. According to Government records, the value of exports increased by 45 percent between 1985/86 and 1989/90 years. However, huge balance of trade deficits continued [63]. For example, in 1990 the country's exports were 429 million in United States dollars while imports were 1.5 billion dollars [42].

The problem of paying full cash cover to the bank has been mentioned in the questionnaire by some maintenance managers sometimes delaying or precluding the importation of goods. The procedure is that after the BOT has allocated foreign exchange to a company, the company is required to pay equivalent cash in local currency before the NBC remits the foreign exchange to the supplier's banker so that shipments can be arranged. Unfortunately, some companies do not have

sufficient cash to pre-pay their imports 8 months in advance and still continue to meet their daily operating expenses, (average lead time is about 8 months).

Some maintenance managers indicated that too many agents are involved. Figures 3-9(a), (b) and (c) show that five agents are involved in the process, including: the BOT, NBC, Customs, Central Freight Bureau and the Tanzania Harbours Authority. Much time is spent dealing with these agents. Some Tanzanian maintenance managers suggested combining or omitting some procedures completely as solutions to this problem. This is possible if the management of the respective agencies is committed to improvement and is prepared to adopt a Total Quality Management (TQM)** approach to expedite the processing of imports.

5.2 Availability of Raw Materials:

A workshop survey on manufacturing capabilities conducted in 1988 [18] revealed that most industrial spare parts can be manufactured locally. However, it is not valid to suggest that spare parts which have been imported can be manufactured domestically without ensuring availability of raw materials and other factors involved in spare parts

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** TQM is defined as performance leadership in meeting customer requirements by doing right things right the first time. It is customer driven. In services, quality is maintained by meeting service standards.

manufacturing. Maintenance managers indicated that lack of raw materials such as special steels, carbon steels, copper and copper alloys is attributable to scarcity of foreign exchange to import them.

Tanzania has the natural resource potential to produce sufficient steels for domestic demand plus a surplus for export [15]. It has large unexploited deposits of iron ore and coal deposits which are not yet exploited effectively. For example, coal in Kiwira and Mchuchuma could be used in the exploitation of iron ore in Chunya and Liganga in Mbeya region. The UNIDO study, "Industrial Development Series", conducted in Tanzania in 1986, found that Tanzania has a deposit of iron ore of about 85 million metric tons in Chunya and Ligangan. The Government, through NDC, is working on a proposal to establish a steel processing industry in the Iringa region, near the sites, which on completion will have a capacity of producing 300,000 metric tons per annum of processed steel [99]. Some initiatives, such as the training of engineers, technologists and administrators, and site development, have already taken place. Table 5-1 provides detail on the iron ore reserves according to deposit. The remaining requirement to build the proposed steel industry is to mobilize the necessary capital.

Table 5-1: Some Deposits of Iron Ore in Tanzania

Regional/ district deposit	Chemistry of reserves		Resources (in million metric tons)	Total resources
	Fe	Other components		
Liganga	49%	TiO_2 13.0%	45	45
Hundusi			8	8
Manyoro	30%	Mn Up to 11%	68	68
			Total	121

Source: "United Nations Survey of World Iron Ore", New York, 1970 page 89.

Though proper analysis of establishing a steel industry as suggested by the maintenance managers is beyond the scope of this study, I would suggest that the economic timing of this suggestion is not good as the international steel market is currently in a recession. For example, the Canadian steel industry is experiencing declining sales and prices [50]. Though the Government of Tanzania has already invested some resources in a steel project, a further economic study should be conducted to re-evaluate its profitability. Declining international steel prices may make it more attractive to import steels rather than produce them locally. However, this suggestion is based on economics, and does not necessarily reflect the political ideology of Tanzania.

Presently, there are two mild steel processing industries in Tanzania. The Steel Cast Company (STEELCO) uses steel scraps to produce ingots and the Tanga Steel Rolling Mill (TSRM) uses the ingots from STEELCO and other sources to produce mild steel bars for the construction industry and industrial uses. Steel production is very low and the quality poor. According to the results of the questionnaire, TSRM provides about 3 percent of the annual national steel requirement.

The National Steels Corporation (NSC), located in Dar-es-Salaam, is a parastatal dealing with the importation and distribution of all kinds of steels to industry. Though, some companies would import steel themselves or obtain it from external donors, the majority depend on NSC for their steel requirements. However, NSC is also subjected to the foreign exchange shortage and its performance is deteriorating.

At present, because of the OGL, a few hardware stores carry substantial stocks of steels and copper alloys, but prices are too high for many potential buyers. For those who can purchase materials, it is difficult to sell their products. However, use of the OGL facility is a common means of obtaining raw materials for those who have their own foreign exchange.

The failure of NSC to supply industries with steel has contributed to rising prices. Open tendering has encouraged private vendors to purchase materials at high prices with the expectation that the scarcity will enable them to make profits on selling them. In this situation, there are no pre-established prices for the materials. This contributes to corruption and the growth of a black market. Furthermore, since many industries have fixed maintenance

budgets they find it difficult to cope with ever changing prices.

The lack of appropriate kinds of raw materials for a particular job is very common. For example the author, during his working experience in a machine shop at Carnot MetalBox (CMB) Packaging Company, encountered several situations where he had to make decisions on the use of unsuitable raw materials. One of the decisions was to use medium carbon steel in place of tool steel to manufacture a clutch key for an eccentric press. The key lasted for only a quarter of the designed life time. The author knew that a medium carbon steel key would not sustain the friction and shear stresses that the original clutch key could because it cannot attain the hardness and strength of tool steel. However, this was the only material available. Tanzania's maintenance engineers are continuously required to consider less than satisfactory alternatives in order to keep equipment operating.

5.3 The Availability of Equipment and Modern Technology:

Lack of modern machinery and equipment for the production of spare parts is not a serious problem; only 13 percent of respondents indicated that they do not have special machinery and equipment for the manufacturing of some spare parts in their workshops.

Availability of mechanical facilities varies widely from one workshop to another. Some do not have any, while others would like to replace their existing facilities with more accurate, faster and higher capacity ones. For example, Tanzania Zambia Railways Authority (TAZARA) indicated that it requires a bigger furnace and higher capacity press to improve its capability to manufacture a wide range of spare parts. Tanzania Automobile Technology Centre (TATC) requires the following machine tools: a new Numerical Controlled or Computerized Numerical Controlled (NC/CNC) machining centre, a helical gear generator, a gear shaper and a slotting/broaching machine. Most of the machine tools mentioned are conventional and can be purchased within the country using local currency, if the companies concerned have enough capital.

Table 3-27 shows that none of the respondents have an NC/CNC machine tool. However, in the Dar-es-Salaam region there are a couple of workshops which have NC facilities. The Faculty of Engineering (FoE) at the University of Dar es Salaam has an NC spark erosion machine which is mainly used for teaching and research purposes, but is available for use by the public in general as well. Other companies which have NC spark erosion facilities are Simba Plastics and Cotex Metals and Machine Tools. These facilities were not designed for public services; their capabilities and

capacities were pre-matched to their respective workshop's spare parts requirements.

The unavailability of foundry and heat treatment facilities was mentioned in the questionnaire; only five of the twenty six companies have heat treatment facilities (see Table 3-27). The majority of workshops do not have foundry shops but do not see this as a problem. Indeed, it is uneconomical to include a foundry in each workshop to manufacture spare parts on an intermittent basis. The availability of foundry facilities nationwide is not a significant problem. For example, in the Dar-es-Salaam region alone there are good foundries at places such as TAZARA, National Engineering Company (NECO), Tanzania Railways Corporation (TRC), Ubungo Farm Implements (UFI), Small Industry Development Organization (SIDO), and TATC, all of which accept outside jobs.

Neither does the unavailability of heat treatment facilities pose a significant constraint to the ongoing manufacture of spare parts locally. The industries concerned could use the few available heat treatment facilities in the country to manufacture their spare parts.

Lack of modern technology is one of the maintenance manager's concerns. Thirty three percent of the maintenance

managers responding to the questionnaire indicated that lack of modern technology is a problem in their workshops (see Table 3-9). Sixty seven percent of the respondents did not have a significant problem regarding modern technology. Although some workshops do not have appropriate technologies to manufacture their spare parts, they can utilize the capabilities of those workshops which have appropriate technologies. For example, there are large workshops such as those of the TAZARA and the TRC, both in Dar-es-Salaam, and Mang'ula workshop in Morogoro region. Though, these workshops were initially designed to service their fleets of locomotives, rolling stocks and equipment, no doubt they can also be used to serve other industrial needs. According to the results of the questionnaire, TAZARA utilizes only 50 percent of its installed capacity. This utilization rate could be improved if other companies took advantage of this facility.

5.4 Lack of Drawings, Tools and Measuring Equipment:

Lack of working tools has also been mentioned by a few companies. The immediate cause identified was lack of funds to import or purchase them locally. Tools such as high speed steel turning tools and milling cutters are not manufactured locally. Mjema [56] indicated that people have a tendency to seek external solutions before exhausting the possibilities of solving a particular problem locally.

Tools which involve forging, machining and heat treatment in their manufacture are available in the country. However, availability of appropriate raw materials may be a problem. The Kilimanjaro Machine Tools Manufacturing Company (KMTMC) has facilities and can manufacture some of these tools.

Seventeen percent of respondents indicated that lack of engineering drawings is a problem in their workshops. Normally, suppliers do not include engineering drawings showing dimensions, materials, tolerances and post treatments together with their spare parts. This information is very important for manufacturing replacement spare parts. Before a worn-out spare part can be manufactured, an engineering drawing is necessary. The job is not difficult if one has proper measuring equipment and the part is still in its original form. However, as the author has mentioned earlier (section 4.3), there is not adequate measuring equipment such as vernier callipers, micrometres and dial gauges in many workshops.

Some workshops such as NECO, TAZARA, FoE, TRC and TATC just to mention a few, have well established design/drawing sections in their organizations. The sections are mainly used for the preparation of engineering drawings from the client's sample parts, drafts or other sources. These drawings can be maintained on file for future reference.

Those workshops without well-established design/drawing sections rely on samples and verbal instructions. A simple draft of a part is made and given to the machinist for fabrication of the required spare part. Rarely are the established dimensions correct. In only a few cases would an organization have formal procedures for the preparation and filing of engineering drawings. For companies without design/draft sections or with poorly qualified personnel, this problem can be solved either by employing qualified draftsmen or by using locally available design/drawing services.

5.5 Observations from MEIDA:

From interviews the author conducted with Mr. Kulwa, a Metal Engineering Industries Development Association (MEIDA) official, information was obtained on the following efforts in local spare parts manufacturing:

(a) MEIDA, under the guidance of the Ministry of Industry and Trade, conducted a survey on gins (cotton mills) spare parts to determine those which can be manufactured locally. Out of this survey a long list of spare parts requirements for all gins in the country was made.

The survey was subsequently extended to other industrial sectors including the Tanzania Cotton

Market Board (TCMB), Sisal Authority (SA), Textile Company (TEXCO) and Automobile Industry (AI).

(b) In October 1988, MEIDA organized an exhibition of spare parts manufacturing capabilities from six engineering workshops. The workshops were those of NECO, Guru engineering, D.M.Investments, Mang'ula Machine Tools, Pamba Engineering and National Engineering Foundry (NEFCO).
The aim of the exhibition was to bring together some local manufacturers and industries to determine those spare parts which can be successfully manufactured. This was probably an effective technique in that it brought together both parties involved in the problem.

As a result of this exhibition, many local parts manufacturers received a lot of orders. But when those who placed orders were requested to make down payments to confirm their commitments, only a few of them managed to follow-through.

Not all manufacturers are conversant with serial (mass) production. This is because they started as repair workshops characterized by manually operated mechanical facilities. Thus, they don't have the capability of

handling large orders or dealing with high volume production. This, in turn hinders their ability to take advantage of economies of scale and to become efficient producers.

Mr. Kulwa also mentioned unfavourable manufacturing processes which increase the costs to the consumer. For example, milling a round bar in order to form a hexagonal shape would be an unnecessary operation if the hexagonal bar was already available as a material. In this particular case, the availability of appropriate raw materials was the problem. Sometimes production processes will depend on availability of facilities. For example, threading a screw may be performed by using either a threading die or a lathe machine. The former means is faster and requires a less skilled operator than the latter, so it is less expensive if available.

The customer often does not have faith in local manufacturers. One of the reasons mentioned was low quality. Parts are less durable than original equipment manufacturers (OEM) and workmanship is poor. The problem of durability may be exacerbated by problems of availability of appropriate raw materials and heat treatment. Customers feel it will take some time before local manufacturers produce parts of equivalent quality to OEM.

(c) After MEIDA realized that problems involved in production of spare parts were extended to other Government agencies such as NSC (for supply of steels), BOT (for foreign exchange availability) and the Ministry of Industry and Trade, it convened another meeting among the parties. The aim was to find possible immediate and long term solutions for the problems that arise during spare parts manufacturing.

The problem of availability of foreign exchange was not solved, as that is a macroeconomic problem beyond the scope of manufacturing industries. The problem of availability of steels was related to availability of foreign exchange. Thus, the solution again comes back to the availability of foreign exchange. MEIDA was to formulate solutions to the problems of availability of raw materials, tools, equipment and payments, but very little progress has been achieved.

5.6 The Shortage of Skilled and Disciplined Manpower:

One of the handicaps within the Tanzanian industrial sector is the lack of sufficient skilled, management-oriented, workers. According to the questionnaire results, 50 percent of the respondents agreed with the above statement. According to Mjema [57], 70 percent of the respondents to the 1990 industrial survey indicated that the low level of skilled technical personnel has contributed to maintenance problems. Spare parts manufacturing, fitting and planning require skilled and disciplined personnel. Poor fitting and planning could accelerate spare parts failure and inadequate inventory maintenance.

The problem of lack of sufficient skilled manpower varies widely with regard to functional categories but in this thesis, only the education and development of technical manpower will be examined. The examination will reveal the difficulties in the education, employment, allocation and development of technical personnel.

Figure 5-1 shows that after primary education, an individual has opportunities either to continue their education in a more academic or Professional (more technical) program. After those joining the secondary education have been selected (usually by the examination board), some of the rest may join the National Vocational Training Centre (NVTC)

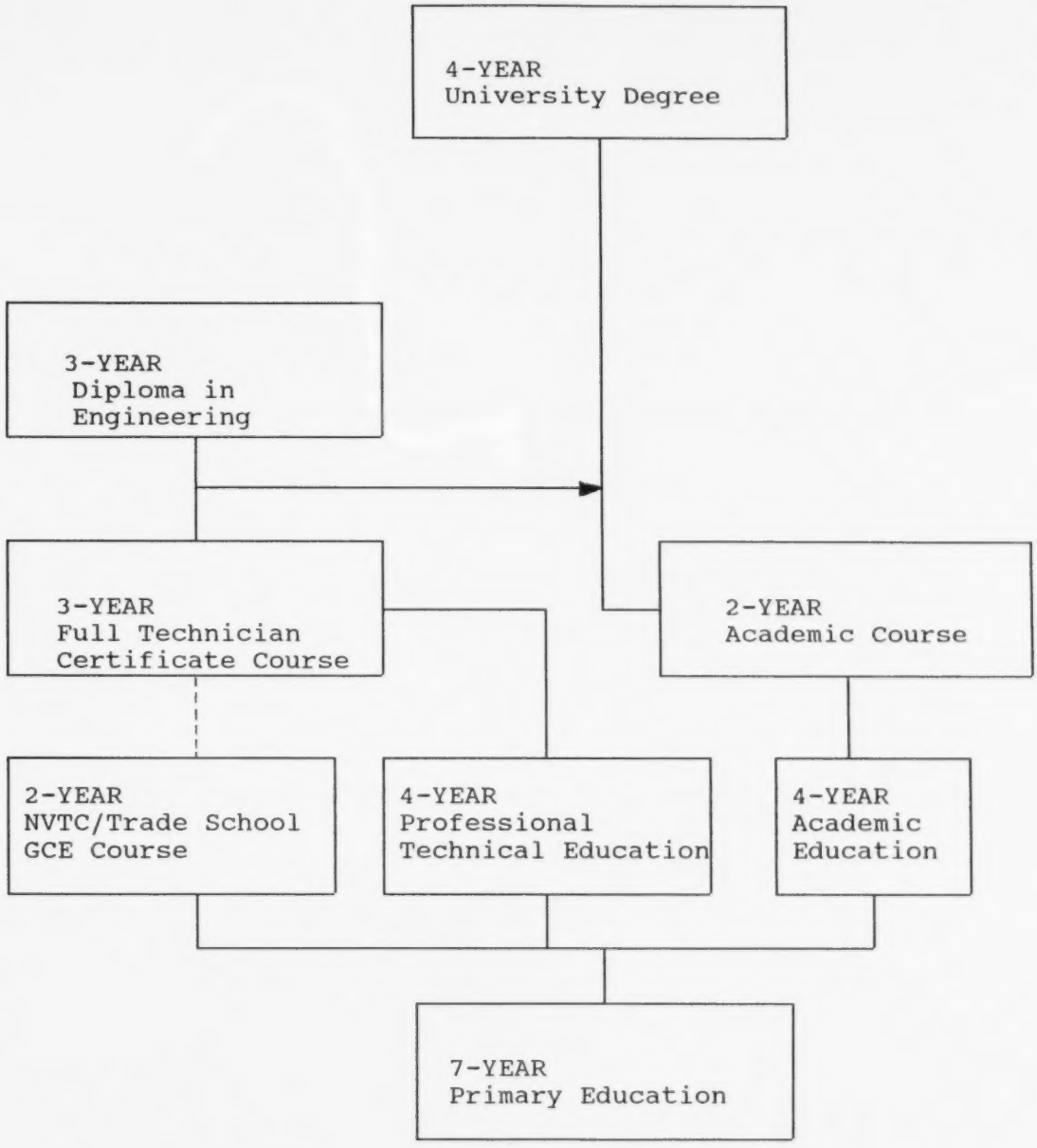

Figure 5-1: Technical Education System in Tanzania

for a 2-year program leading to the General Certificate in Engineering (GCE). The vast majority of pupils are not successful in obtaining chances for further studies, and go to town looking for jobs or stay home in the villages.

During 1979 to 1986, Tanzania's primary leavers (standard vii) enrollment increased by more than 50 percent: from 192,000 to 391,000. In 1979 about 9 percent of the leavers had a chance to become enrolled in a secondary school (17,239). This privilege was considerably reduced in 1986 in relative terms and only about 6 percent could enter these secondary schools [5]. Also see Figure 5-2.

The figures for those who join the NVTCs were not available, but only a few, full-time and part-time students had opportunities to enroll in vocational colleges [36]. Graduates from the NVTCs or trade schools may be employed as artisans grade III***. Student acceptance ratios in the trade schools in most cases are about one percent of applicants for any particular year [38].

Artisans grade III may upgrade to grade I through a series of classes and practical training and a few top grade

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***The term "artisan grade III" in Tanzanian context refers to a person who has passed trade testing grade III after 7 years primary education followed by 2 years technical education in a vocational trade school.

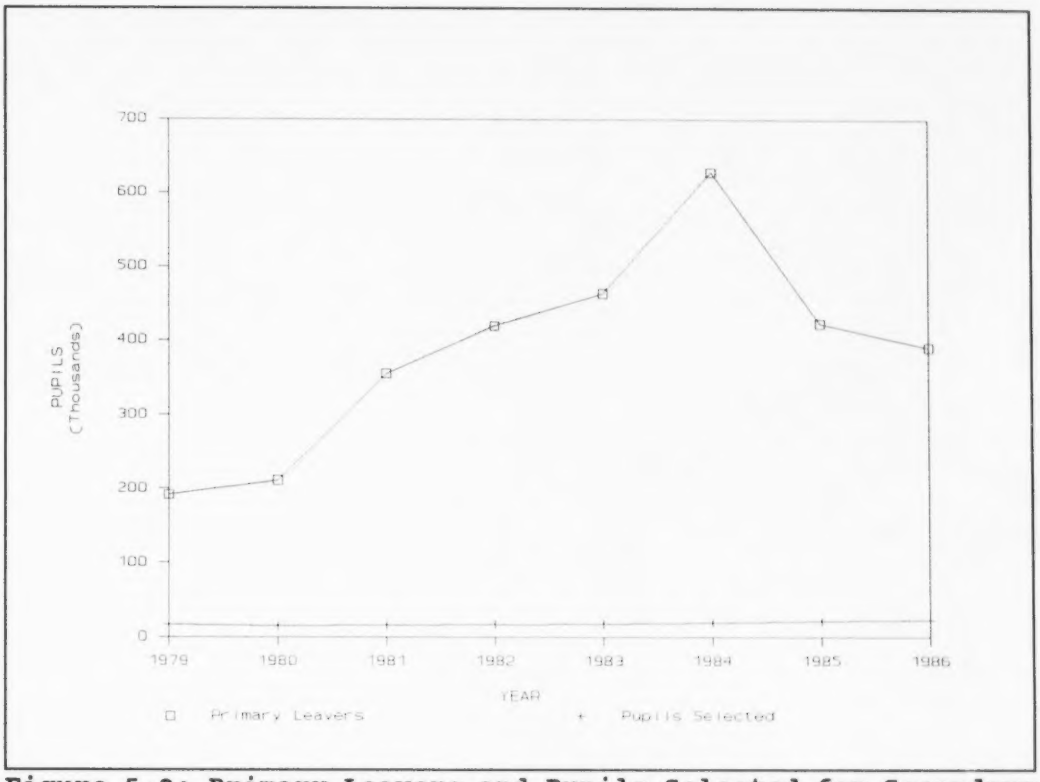

Figure 5-2: Primary Leavers and Pupils Selected for Secondary Education

artisans may be admitted to a Full Technician Course (FTC) at a technical college. However, this is a special case, as most FTC students originate from technical secondary schools.

Some companies felt that graduates from Technical Secondary Schools were not well-enough trained. Thus, many workshops preferred to train their own craftsmen in-house [39]. Secondary school graduates are not given enough Industrial Training (IT) in order to gain skills. These graduates require training directed to their future working fields.

Industries should not expect miracles if they don't support these young graduates. They should provide time, facilities, assignments and even moral support.

The in-house or on-the-job training typically involves training an individual to perform only a limited range of functions and most trainees are primary school leavers. The worker would receive mainly practical skills and very little know how. Later, they may enroll for the trade test grade III examination in the NVTC. Artisans form the low level technical personnel and are the vast majority of a workshop's manpower in Tanzania's industries. In spare parts manufacturing, artisans are good in machining but may have difficulties in interpreting complicated drawings and heat treatment procedures. They require close supervision by a technician or an engineer.

According to Government statistics, in 1981-82, only 352 first year students were enrolled in FTC courses [6]. Figure 5-3 shows that the number of first year technical students enrolled in the period 1982-83 to 1985-86 at least remained constant. In 1986-87, a jump in the number of students enrolled was due to the establishment of the Mbeya technical college. However, data on manpower requirements for technicians is not available, so how far this went towards solving the problem is not known.

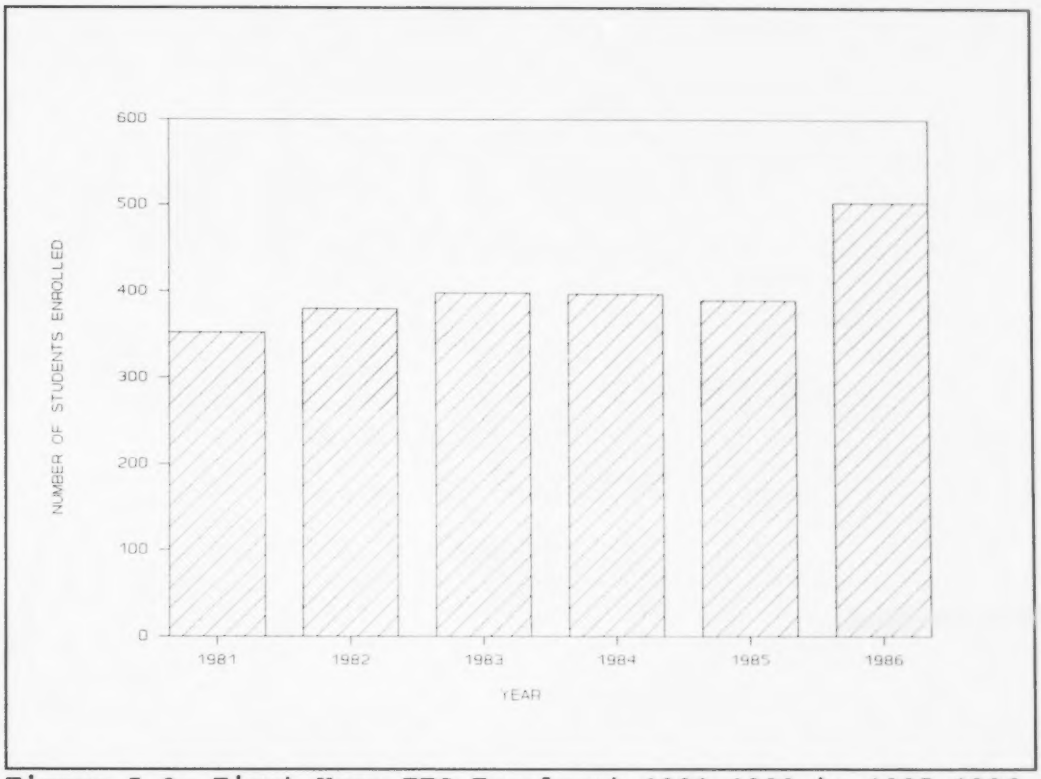

Figure 5-3: First Year FTC Enrolment 1981-1982 to 1985-1986.

Source: Data from the Bureau of Statistics, Ministry of Finance, Economic Affairs and Planning, Dar-es-Salaam. October 1988, page 63.

It normally takes 3 years before a student writes the national examination in FTC courses. Students with top performances may enroll for a Bachelor of Science degree at the University of Dar-es-Salaam, Faculty of Engineering (FoE), (the only university which offers engineering courses) or enroll for diploma courses. The rest of the students are posted in industries or institutions to work as

technicians. It is unfortunate that opportunities for further studies is limited. For example, in 1981-82, 332 third year FTC students were enrolled, but only 129 of these students (39 percent) were admitted to diploma courses. In 1985-86, 101 out of 390 third year students (26 percent) were admitted to diploma courses in 1986-87 [7]. Figures for those who were admitted to the Faculty of Engineering (FoE) at the University of Dar-es-Salaam were not available.

The majority of students entering FoE come directly from high school (normally those with a background in science subjects, mathematics being compulsory) [34]. Table 5-2 shows that only 54 out of 61 who enrolled in the 1973/74 academic year completed the FoE's first Bachelor of Science program. After 7 years (in 1984), the number of graduands increased by 60 percent. Up to 1984, it was believed that FoE's graduates accounted for about 40 percent of the total number of qualified Tanzanian engineers trained and absorbed in different sectors of the economy [107].

The estimated number of engineers (in Civil, Mechanical and Electrical engineering) required for the period 1975-80 was 764. This is about 80 percent of Tanzania's total requirements of engineers for the same period [1]. Table 5-3 shows the total requirements of engineers, including vacant posts.

Table 5-2: Bachelor degree awarded by FoE

Discipline	1977	1978	1979	1980	1981	1982	1983	1984	Total
Civil Eng.	28	37	24	46	63	55	53	57	363
Mechanical Eng.	20	27	16	34	27	33	34	32	223
Electrical Eng.	6	13	13	11	20	14	8	17	102
Process Eng.	-	-	-	-	-	11	12	14	37
Chemical Eng.	-	-	-	-	-	-	11	15	26
Total	54	77	53	91	110	113	118	135	751[****]

Source: FoE-University of Dar-es-Salaam, graduate and employer survey 1985.

Table 5-4 gives an estimate of the number of engineers who graduated in each field during the same period. About 60 percent of the demand for engineers was filled by the University of Dar-es-Salaam. If citizen wastage and localization had not occurred during the period, about 86 percent of the demand for engineers would have been met. Indeed, one has every reason to believe that availability of engineers is not a serious problem, and a meaningful contribution from these experts can be expected unless they are not properly utilized or are not employed.

[****] This is by the 1983/84 Academic Year. 141 engineers have graduated in 1985 and brought the total to 892.

It is likely that data on Tanzania's engineers is not accurate. For example, in 1974 there were 275 civil engineers [1], but a manpower survey carried out by the Ministry of Manpower Development and Administration (MMDA) reported that 339 civil engineers were employed by 1980 [52]. This implies that of 135 civil engineers graduates between 1975-80 [55] (FoE only), only 64 were practising as civil engineers.

There have been some observations that many Tanzanian engineers are under-utilized; they are not assigned duties equivalent to their educational qualifications [58,108]. Because of this under-utilization, some engineers either quit or continue to work with low moral. Some companies responding to the questionnaire indicated that they lack engineers. This does not mean that engineers are unavailable in the country. The problem is how they are allocated and utilized.

Effective manpower utilization is very much dependent on the correct allocation. According to a 1985 survey of graduates and employers, 84.5 percent of the respondents indicated

Table 5-3: Total Requirements for Mechanical, Civil and Electrical Engineering 1975-1980

OCCUPATION	VACANT POSTS (74)	NET INCREASE IN POSTS (1975-80)	CITIZEN WASTAGE	LOCALIZATION	TOTAL REQUIREMENTS
Civil Engineers	150	180	7	130	467
Mechanical Engineers	48	130	8	70	229
Electrical Engineers	16	31	3	18	68
Univ. Teachers (Eng.)	9	50	-	-	59
Tech. College (Eng.)	49	15	-	16	80
	272	379	18	234	903

Source: Annual Manpower Report to the President - 1972

Table 5-4: Output of Civil, Mechanical and Electrical Engineers 1975-1980.

OCCUPATION	1975	1976	1977	1978	1979	1980	TOTAL
Civil Engineers			28	37	24	46	
Mechanical Engineers	32*	26*	20 + 17*	27 + 47*	16 + 26*	34 + 33*	
Electrical Engineers			6	13	13	11	
	32	26	71	124	79	124	456

* Graduates from abroad (Total)

Source: **University of Dar-es-Salaam and Ministry of Manpower Development and Administration.**

that the manpower allocation system required improvements and one of the deficiencies mentioned was that the preferences and educational background of the graduates were neglected [29].

In Tanzania, the scarce high level manpower resources, engineers included, are tentatively allocated by the (MMDA) and ratified by the High Level Manpower Allocation Committee (HLMAC) according to their interpretation of demand in the economy. The factors governing allocation are numerous, such as the national interest and commitment, the ability to predict actual requirements, and individual preference. According to Bundala [109], the allocation criterion may have the following deficiencies:

(a) Some of the indenting authorities are not competent enough to correctly identify their actual requirements. Thus, once the allocated engineers realize that they are not in the right organizations, some either change employers or self employ without even communicating to the MMDA.

(b) The HLMAC does not seem to have the capability to deal with engineers and related scientists.

(c) The allocation excludes the private sector which is the most rewarding in terms of monetary rewards and job satisfaction. There are no restrictions on engineers wishing to move from the parastatal to the private sector. As a result, quite a number of engineers move into the

private sector. This drift of engineers into other sectors is probably the major contribution to the so called wastage of engineers.

(d) There is no follow-up once allocation is made to monitor the effectiveness of the process.

Many Tanzanian engineers in the public sector don't earn enough salary to meet their basic needs. They subsidize their living costs by doing private jobs during private time, and sometimes even during office hours. Though this is illegal, it is a normal means of survival in Tanzania. The problem of salaries is recognized by the State and each year the minimum wage is raised, but living costs also increase and at a faster pace. An obvious solution suggested by maintenance managers is for companies to motivate their personnel by providing attractive salaries.

Another possible motivator is proper utilization of engineers by assigning them duties commensurate with their academic achievements, for example, by providing them with challenging assignments. This may provide opportunities for job satisfaction and at the same time offer valuable experience.

The manpower allocation should include the private sector because both sectors (public and private) contribute to the

country's economy. This will reduce the drifting of engineers from the public to the private sector. Thus there is a possibility that people may work for their companies for a longer period.

The manpower allocation should match closely job descriptions and preference of the candidate. The success of a candidate in his/her career will depend on whether he/she likes it. Another possible method of career placement is to leave matters to the engineers to chose where they want to work. Letting employers do the hiring and graduates do the job seeking might lead to a better match between employer requirements and individual skills and interests.

For both semi-skilled and skilled manpower, there is a need to continuously increase their knowledge through further education and training. Therefore, companies should formulate training programs and provide adequate learning opportunities. Personnel required to attend training should be supported by the company. Providing this support may make the personnel more committed to their companies.

5.7 Inventory Management:

This section will address problems related to spare parts inventory. Many stores are kept by unqualified personnel, spare parts transactions are not adequately recorded and the instituted systems are not followed. Therefore, the following areas will be examined: storekeeping personnel, stores systems and spare parts records.

5.7.1 Storekeeping Personnel

Thirty eight percent of the companies interviewed admitted that they do not keep records. This suggests that they either do not have qualified personnel or instituted inventory systems are not followed properly. Table 4-2 shows that only 38 percent of respondents have trained storekeeping personnel. This suggests that most stores are managed by unqualified people. This section attempts to examine training systems for stores and materials management personnel.

The normal system of developing storekeeping personnel by Tanzanian enterprises is on-the-job training. It normally starts with an orientation for new recruits and then is followed by the on-the-job training. Some of the recruits do not have a primary education. As a result they find it difficult to speak, read and write well in English which is the language of business. These people find it difficult to

process spare parts transactions. Those individuals with appropriate education may attend certificate courses offered by a variety of institutions. Certificate and diploma courses in stores/materials management are offered at some institutions such as the Nyegezi Social Training Centre (NSTC), the Dar es Salaam School of Accounts (DSA) and the Institute of Development Management (IDM).

According to available statistics, 75 students in 1985/86 were enrolled in certificate programs and 26 in diploma programs in materials at the DSA [8]. At IDM, 75 students were in advanced diploma courses [9]. Also in the same years at NSTC there were 50 students enrolled in stores management [10]. Though, the manpower requirement was not known, the effort to train stores/materials management personnel is quite substantial, especially considering the vast majority who graduate in private studies. The question to be asked is why there is still a shortage of trained storekeeping personnel when a substantial number of people have been trained. Maintenance managers interviewed suggested that some companies do not pay competitive salaries. As a result people are not attracted to fill vacant posts.

Not all Tanzanian firms maintain a policy of employing qualified personnel. Private firms are more interested in one's skills rather than education achievements, and they do

not have manpower development policies. Firms dominated by foreign nationals frequently demonstrate less willingness to train their personnel [23]. Parastatals provide training opportunities to their employees. The training may be influenced by personal initiatives such as ambitions, tribal prejudice and competitive fears or may be according to company plans. The author observed from the questionnaire results that quite a few parastatal firms indicated they do not have trained storekeeping personnel. The problem of unavailability of qualified stores personnel is believed to be attributable to the unfavourable employment policy and lack of training after employment. A problem to be addressed is why some companies employ unqualified storekeeping personnel and don't develop them by providing training opportunities.

Two possible causes for the employment of unqualified personnel are low wages and inadequate job descriptions. Low wages may not attract qualified people to fill vacant posts and due to lack of job descriptions, appropriate candidates may not be determined. Some companies are reluctant to spend funds for training their personnel. Although Government policy emphasizes the training of workers, it does not follow-up in order to ascertain the implementation of its policy. These problems are within the scope of industries to deal with and the maintenance

managers suggested that employment policies should be followed and attractive wages paid.

5.7.2 STORES SYSTEMS:

Some Tanzanian industries do not maintain their already established spare parts systems. Spare parts are issued without adequate records. This is a responsibility of stores personnel. Some maintenance managers interviewed stated that they find it difficult to maintain their systems because of shortages of spare parts. A lot of paper work is required to keep records and this adds to costs. But regardless of some empty shelves, a system has to be adopted in order for the spare parts to be accessible.

In the case of small industries, the system may consist of a simple list showing withdrawals and deliveries. In the case of large industries, the stock situation requires more careful control. The spare parts systems can be used to control:

- what parts are stocked
- order point and quantity
- max. quantity in stock
- min. quantity in stock
- delivery control
- quantity ordered
- current quantity in stock

Figure 5-4, describes the basic economic order quantity associated with stock holding theory. In Tanzanian firms this stock holding theory is rarely followed. The maximum number in stock cannot be maintained when spare parts are ordered, and the reason is unavailability of funds, and if the part is foreign, it is much more difficult to obtain. In some cases, companies run out of stock. Thus, they operate below the predetermined minimum level of stock. Some companies wait until all stocks are fully depleted before replenishing them even if the spare parts are locally available. Sometimes, only required amounts are ordered to solve a particular problem. For example, a broken down electric motor requires a bearing to be replaced. Normally they would order only one bearing in order to solve the problem at hand. But, for this particular case, one should consider replacing both bearings and keeping at least one pair of bearings in stock to have them ready in case of another unpredicted breakdown.

In the Tanzanian situation, to maintain spare parts inventories is very important because of long lead times required to obtain additional spare parts. This will reduce the mean time required for repair of the machine. But, at the same time, it is desirable to avoid excessive investment in spare parts. Industries in the Western World have

adopted "just in time"***** inventory management in recent years which results in much lower levels of "maximum number in stock" inventories being maintained. This practise is a result of the introduction of computerized stock-keeping which improved the ability of managers to manage inventories. The end result is lower inventory costs and lower production costs in these industries.

5.7.3 Spare Parts Records:

Thirty eight percent of the industries responding to the questionnaire were not able to report their spare parts financial data. For those that reported, the data was suspect; the persons interviewed seemed to rely on their own recollections and not on recorded data. Some argued that the information is confidential. Thus, it was difficult to get reliable data. Spare parts withdrawal from stores should be adequately documented. The information may be used for future inventory and maintenance plans.

A spare part withdrawal from stores could be initiated by a breakdown or a Preventive Maintenance (PM) inspection in the plant. A work request is filled and received at the maintenance planning office. The maintenance planner then issues a work order and spare parts requisition. The spare

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***** Just In Time (JIT) is a TQM tool which emphases on timing of operations. In inventory, it is employed to determine when and how much to stock.

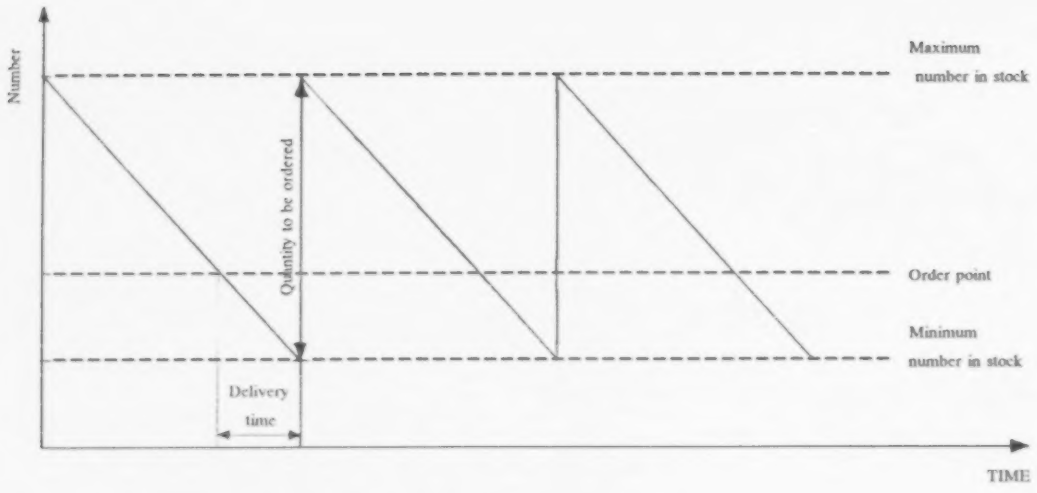

Figure 5-4: Stock Holding Theory.

parts number, quantity, etc, are entered in the unit records. Finally, a withdrawal from stores is made and recorded on the material card. After a spare part has been issued, the data from the material card is entered on the spare parts card and the current quantity is changed and compared with the order level. At the end of the week, or when the work order is closed, the material cards are sent to the maintenance planner for follow up.

Most Tanzanian industries do not approach maintenance activities systematically. Important information is passed verbally. For example, at CMB Packaging Limited, some steps are omitted. A job requisition will be completed by a requester at the maintenance office and used for the spare

part withdrawal. The important documents such as unit records and work orders are disregarded. With this inadequate documentation it is virtually impossible to plan spare parts requirements. Because of a lack of past data, forecasting of required parts cannot be determined. This problem is attributed to poor management in that it does not emphasize proper data documentation.

Spare parts systems currently used in some Tanzanian industries lack proper coordination between the accounting and maintenance departments. The cost aspect is normally overlooked. The price of a spare part should be entered on the material cards, and at the end of the day all data on the material card transferred to the spare parts cards. Again, at the end of the week all material cards are sent to the maintenance planner for cost control of spare parts. The documentation of costs of spare parts consumed will help to analyze maintenance costs for each machine and for the entire department.

5.8 Marketing Strategies:

Traditionally, marketing was not a problem for Tanzanian industries; they sold what they made [31]. The Government protected the companies by providing market monopoly. Recently, business has become subject to more competition due to a shift to a freer market economy. Now there are cheap imports and wider choices of products. Local spare parts manufacturers don't receive as many orders, and as a result their production capacities are under-utilized. This was suggested to the author by maintenance managers as a marketing problem. It might more correctly be described as a competitiveness problem.

As mentioned regarding MEIDA's local spare parts exhibition (section 5-5), spare parts manufacturers involved in the exhibition received orders beyond their capacities [47]. Thus, the MEIDA exhibition was a very effective marketing promotion, helping to bridge a gap between manufacturers and their clients. However, MEIDA's initiative was a failure as it didn't provide a lasting strategy.

5.9 Local Quality:

According to the questionnaire results, quality is not a major problem in the eyes of many Tanzanian manufacturers. Only 17 percent of the respondents of the questionnaire felt that they have a problem with quality in the spare parts

they manufacture. Although some companies do not think they have a quality problem, it seems their customers do think so. They show their displeasure by buying foreign goods whenever possible. The concept of quality is not well understood by many Tanzanian manufacturers. Quality must be defined as fitness for use as anticipated by a customer, not the supplier. In terms of time, quality is a dynamic target [22]. Quality will start from material selection and extended to workmanship, and finally a customer will judge the quality of a final product. A bronze bushing, for example, may fit properly into an assembly but if it wears faster than its anticipated half life, then the bushing is of low quality.

Tanzanian spare parts manufacturers are facing a number of handicaps which make it difficult for them to manufacture spare parts of high quality. The workshops lack proper tools and measuring equipment, proper raw materials and accurate machine tools. The problem of quality will persist until the above problems are solved. Unless dramatic changes are made in the workshop structure, a tendency to prefer import parts rather than locally made parts will continue. After all, no one is willing to purchase low quality parts.

5.10 Reconditioning of spare parts:

Not all Tanzanian industries utilize the existing spare parts reconditioning capabilities in the country. Some prefer to purchase Original Equipment Manufacturer (OEM) parts even if possibilities of reconditioning existing parts are available. This has been partly attributed to the fact that the reconditioning techniques are not well-applied.

The following example taken from the author's experience illustrates the dilemma. The crown gear of my car suffered a broken tooth. The mechanic offers two alternatives to rectify the problem:

Alternative 1: buy a new crown gear at $270 with a labour cost of $75 (5 hours at $15 per hour) for installation.

Alternative 2: repair the broken tooth at say $50 (labour and material included) and labour charge of $75 to install the gear.

The question as to which alternative is suitable is not a simple economic one. Although I was assured that the car will work well for either of the two alternatives, I could not rely on the mechanic's assurances. It is common to insist on genuine replacement parts because of assured material quality. But, the choice is further complicated by constraints that might preclude obtaining a new part.

Constraints such as lack of funds, unavailability and/or late delivery of the part.

Another example from the author's experience at CMB Packaging Limited (the former Metalbox company) illustrates some of the problems discussed. One of the air compressors was not producing sufficient air to run the production machines. The cause of the problem was a worn out cylinder bore which allowed excess air to escape during the compression stroke. The bore already exceeded the maximum bore limit. The standard company policy was to replace the compressor. However, they did not have one in stock and since the compressor is obsolete, spare parts could not be obtained from the manufacturer.

As Engineering Superintendent, responsible for any action to be taken, after reviewing the alternatives I decided to rebore the cylinder to oversize allowing a sleeve to be inserted by press fitting. Both the cylinder and sleeve were made of the same material (cast iron). Then the assembly was rebored to the recommended standard size. Workers re-assembled the compressor and tested it. It worked and the problem was solved. In this instance local repair proved to be correct alternative but, since it was not policy, it was only done as a last resort.

Today there are a variety of spare parts reconditioning techniques available. It is economical and convenient to purchase a less expensive shaft rather than attempt to recondition an older one of higher quality. Conversely, it is uneconomical to scrap a two-metre kiln drive gear wheel which can be repaired. It would seem that repair alternatives employing new technology are not being actively used in Tanzania.

Commonly known techniques in the country are: metallizing, thread inserting, metal stitching, metal spraying and other metal depositing processes. Meida Maintenance Services Limited (MMS) is the only maintenance company in the country which offers a full range of maintenance services (see Appendix II). Quite a few workshops have reconditioning equipment; according to the survey, only 9 percent of industries have metal spray equipment. This means that the other 91 percent depend on MMS. If industries fully utilize MMS's services, no doubt the demand would exceed its capacity. But, MMS indicated that it does not receive adequate orders from industries.

Many companies may attempt to recondition spare parts within their maintenance workshops. Due to lack of proper facilities and improper work procedures, they do not get good results. For example, re-building a worn out shaft by

arc welding will have problems related to uneven heat distribution which results in bending or warping of the shaft. Furthermore, the heating effect may cause metallurgical changes. This impairs the performance of the spare part. The same shaft, if metal sprayed (heat input to the shaft is controlled), will not bend or warp. The crude ways of doing some reconditioning jobs have been partly attributed to lack of technological know-how.

All materials and consumables required for metal spray processes such as electrodes and metallic powders are imported into the country. Their availability in the country will depend on foreign exchange availability. Other materials that must be imported are special alloyed welding electrodes, metal cutting tools, consumables and reconditioning equipment. Their availability depends on the state's foreign exchange reserve.

5.11 Maintenance Practices:

This section is intended to examine possible causes of problems related to unsatisfactory maintenance practices. Further discussion will extend to how maintenance practices affect the provision of spare parts in Tanzanian industries.

5.11.1 Maintenance Procedure:

Unsuitable maintenance procedures is a problem in some Tanzanian industries. For example, a common practice is only to repair a machine after it has broken down. With this practice, proper inventory of spare parts is difficult because of unpredictable demands, as spare parts are purchased only when a breakdown occurs. But due to long lead times of obtaining spare parts the repair work is delayed and this adversely affects production.

Machines, spare parts, and all types of equipment have their own unique lifetime. This suggests that no universal maintenance procedure can be adapted to all facilities. Each facility calls for a certain maintenance procedure suitable to it. For example, the individual life of ball bearings follow a random curve; failures are distributed in time, so they cannot be predicted. In this particular case, Condition Monitoring (CM), may be adapted to detect if any failure has developed. If a failure cannot be predicted in advance, Preventive Maintenance (PM) cannot be applied.

Instead, Breakdown Maintenance (BM) may be suitable. Figure 5-5 shows failures and their development. This figure may be used to establish an appropriate maintenance procedure for a unit.

As mentioned earlier, Some Tanzanian industries do not have adequate technical manuals or other working instructions. The establishment of maintenance procedures may be difficult. Further, lack of skilled technical personnel deters efforts to establish good maintenance procedures. The problem of obtaining adequate technical documents (manuals, list of spares, maintenance schedules, operator and engineer training aids) are dealt with in the section dealing with procurement. However, many people procure equipment without taking maintenance into due consideration [96].

Some Tanzanian industries have a problem with the provision of adequate technical documents required for efficient maintenance work. In some cases, technical manuals are written in foreign languages unknown to users [59]. For example, in CMB packaging company limited, machines manufactured from Germany and Italy were supplied with technical manuals written in German and Italian, respectively. None of the users can read and interpret the languages. The provision of appropriate manuals seems to be

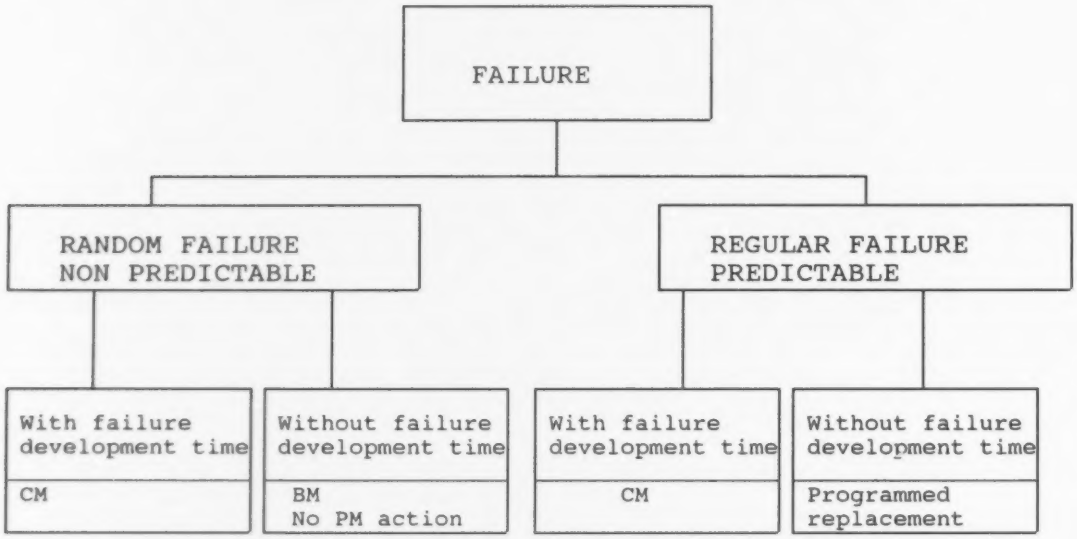

Figure 5-5: FAILURES AND THEIR DEVELOPMENT

a purchasing problem. As equipment is normally supplied with a multi-lingual manual. When a manual written in English is not supplied, on request, the english version should be available. Also, in this area, MMS (appendix II) can help to establish necessary technical documents required for maintenance of machines.

Another problem is lack of working tools. There are no maintenance facilities that have sufficient equipment such as measuring, testing and inspection equipment, torque wrenches, spanners and pullers. The equipment available has to be shared among a number of maintenance personnel and this often delays scheduled jobs. In some cases, maintenance personnel attempt to improvise tools and techniques to compensate for unavailability of proper tools. For example, removing bearings by means of hammering instead of using pullers. This practice may cause much damage to other items in the assembly. In this particular example, hammering may cause dents to a shaft, and before fitting a new bearing the shaft should be smoothed. This prolongs the maintenance time and probably reduces the quality of the maintenance effort. An investigation made by a shipping line into maintenance activities showed that improvisation is one of the factors contributing to excessive down-time [102].

The problem of availability of adequate maintenance facilities is especially serious for maintenance of modern equipment. They must be well-assembled, tested and adjusted in accordance to precise specifications. Spare parts, if not well fitted, fail faster than expected. Thus more spares will be required than normal. In some cases, industries in Tanzania depend completely on the skill and ingenuity of their engineers without supporting them with adequate facilities. This is one of the factors which causes job dissatisfaction, frustration and low moral for maintenance personnel. With management support, some maintenance facilities such as gigs, slings, hummers and pullers can be manufactured with workshops. Though this will require funds to purchase some materials, it is cheaper than purchasing already made facilities.

5.11.2 Maintenance Records:

Most of the workload for a maintenance manager consist of collection and transferring of data concerning the plant and equipment, maintenance work performed and work to be performed. If the maintenance department is not well administered and the work not systematized, maintenance managers will lose control of the situation. The department may work very hard but not efficiently. This will result in frustration within the maintenance department, frequent stock-out of spare parts and low availability of the plant.

Most Tanzanian industries, record insufficient maintenance data. This is supported by the fact that in the questionnaire results, only about 38 percent of industries provided data for their annual spare parts budget. Further, only 50 percent reported data on investment in equipment. This shows the inadequacy of records, and thus provides little information for maintenance management. Data from the material card, if recorded properly, could have provided costs of spare parts and provided means of assessing spare parts usage for individual equipment.

5.11.2.1 Spare Parts Consumption:

Spare parts for each equipment should be well documented with the following details: drawing number, spare part number, supplier and delivery time when ordered from the supplier; see Figures 5-6(a) and (b). According to an UNIDO study in maintenance and repair in developing countries, it was noted that maintenance reports are meagre and not well-presented [97]. Individual records of spare parts use is very important for cost and stock control. As mentioned earlier, if all spare parts are recorded, it is often possible to optimize spare parts stocking (recall the comment above re "just in time" inventory management, and its reliance on comprehensive records). As equipment requires more maintenance with age, more spare parts may be required, and hence the increase in maintenance costs [101].

UNIT CARD

NAME:		UNIT NO.
		ACCOUNT NO.
		PLANT AREA
ASSEMBLY DRAWING NO.	MANUFACTURER	MANUFACT. DRAWING NO.
SUPPLIER	TYPE	SERIAL NO.
DATE OF DELIVERY	ORDER NO.	PRICE
IDENTICAL UNITS	TECHNICAL DESCRIPTION	

REPAIRS AND MODIFICATIONS

DATE	W.O NO.	DESCRIPTION	NO.OF MEN	TIME USED	SPARE PARTS	COST

Figure 5-6(a): Unit Card-(Front).

SPARE PARTS

QTY	DESCRIPTION	TIME	DRAWING NO.	SPARE PART NO.	SUPPLIER	DELIVERY TIME

Figure 5-6(b): Unit Card-(Back).

From an engineering perspective, excessive usage of spare parts may indicate flaws in the design of equipment or low quality spare parts. If spare parts consumption can be closely monitored, it may provide clues to these engineering problems and allow corrective measures to be taken to rectify the problem.

5.11.3 Maintenance Personnel:

In some Tanzanian industries, it is common that spare parts cannot be financed because a particular industry does not have funds. The pre-determined maintenance budget may be exhausted. This may be due to high operation costs, including wages, and low efficiency in executing maintenance activities.

According to the questionnaires results, the median class of maintenance personnel as a percentage of all employees is 3 to 10 percent. This result may suggest that all industries with over 10 percent maintenance personnel compared to total employees are over-staffed. Table 5-5 shows maintenance cost indicators by industry based on a survey carried out by the British Government in 1969/70. Though these figures cannot be taken as a governing rule, they provide a guide to assessing maintenance costs.

It is obvious that, if some funds can be saved from salaries and other maintenance costs, they may be used for procuring

more required spare parts. Scheduling and timing of maintenance activities will help to save time and resources involved in handling maintenance emergencies.

5.11.4 Unit Record:

A unit record is an important tool for the planning and implementation of maintenance. Working tools, spare parts, drawings and technical documents, safety regulations and data from similar repairs and modifications are stored in a unit record. All spare parts in stock are recorded, as well as those used for repair and modifications.

Advantages in using unit records are:

- Maintenance processes are less dependent on individual experience and recollection.
- It is often much easier to keep records of fixed assets, insurance policy values, etc., up-to-date.
- The technical data record makes standardization more simplified.
- Experience of the present equipment may provide useful information for further decisions.
- It makes it easier to find special tools, safety regulations, components, spare parts, particulars of drawings and instructions. Hence, time required for maintenance repair is reduced.
- It is possible to optimize spare parts stocking.

Table 5-5: Maintenance Cost Indicators by Industry (Percentage)

Item	Food, drink & tobacco industry	Paper, publishing & printing industry	Textile industry	Engineering industry (excluding electrical engineering)	Electrical engineering industry	Metal goods manufacture	Clothing & footwear
Maintenance cost as percentage of sales value	1.94	3.87	3.16	3.44	2.36	2.75	2.44
Maintenance costs as percentage of net output	6.92	8.17	8.62	7.6	4.27	7.26	5.35
Maintenance staff as percentage of total direct labour	12	9	10	11	10	13	4
Maintenance staff as percentage of all employees	8	7	7	7	5	7	3
Maint. labour allocations							
Plant & equipment	57	62	68	52	73	70	68
Building	7	12	17	19	11	7	15
Capital projects	13	7	5	13	5	11	6
Services	16	17	9	12	6	8	10
Maint. cost allocations							
Internal maint. dept.	98.8	92.3	99.6	89	90	99	100
Labour	42.8	51.2	40	39	31	51.8	34
Materials	29.7	24.4	35.5	21	20	5.2	36
Overhead charges	27.5	24.4	24.5	40	49	43	30
External labour & contract maintenance	1.2	7.4	0	10.8	9.8	0.6	0
Maintenance by prod.: personnel	0	0.3	0.4	0.15	0.2	0.4	0
Division of maint. cost:							
Planned work	41	49	26	16	29	20	23
Breakdown work	30	11	34	46	39	63	35

Source: British Government, Industrial Maintenance Survey in 1969/70. UNIDO, Report, ID/156, New York, 1975.

6.0 A Case Study of STAMCO Machine Shop:

6.1 Selection of the Company:

Specialty Tool And Manufacturing Company (STAMCO) Limited in Edmonton, Alberta, agreed to participate in the study of industrial spare parts inventory and manufacturing in Tanzania. STAMCO is used as an example of a Canadian company. However, no other shops were investigated to determine if STAMCO's practices represent industry norms.

6.2 The Company:

STAMCO was established in 1979, and its motive is to serve Canada's growing industries. It is located in the south east side of Edmonton, at 6048 and 97th street. STAMCO offers a wide range of services to industries around Edmonton. The services include manufacturing of molds, dies, identification tags and various spare parts.

STAMCO employs 30 workers of which 23 are direct labour, one is a maintenance person and the rest are working either in the office as clerks or management staff. In 1990, sales were $2.0 million, with net income of $200,000 (10% of sales). Net fixed assets (machinery and equipment) at the end of 1990 was $500,000, with fixed assets turnover of 4.0 times (ratio of sales to fixed assets), indicating that the firm is using its fixed assets effectively. Current assets data was not available.

6.2.1 Workshop Equipment:

STAMCO machine shop is equipped with various machine tools and equipment used for manufacturing and reconditioning of spare parts, molds and dies. Most of the machine tools are conventional and semi-automatic operated. These include several lathes of different sizes (swing), surface grinders, radial drill machines, horizontal/vertical boring machines, milling machines and engraving machines. The most impressive thing about the machines is that despite their old age, they still operate very well. This is contrary to Tanzanian experience where inaccuracy of machines was associated with their age, and was reported as a serious problem.

STAMCO has also invested in modern machine tools. There is a mold and die manufacturing machine which employs electrical discharge machining technology, and a CNC milling machine. These machines are high precision machine tools which are required for high precision jobs such as die and mold production. Other supporting equipment include three furnaces for heat treatment, welding equipment (TIG*, MIG**,

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* Tungsten Inert Gas (TIG) welding or in Europe it is called WIG welding, using *Wolfgram*, the German word for tungsten, is an arc welding process which produces coalescence of metals by heating them with an arc between a tungsten electrode and work. The electrode is non-consumable metal, and shielding is obtained from a gas or gas mixture.

Stick welding, etc.) and a tap disintegrator.

6.2.2 Organization Structure:

Figure 6-1 shows STAMCO's organization structure. The president is the head of the company, and he is responsible to the board of directors. Below the president is the vice president who is in-charge of the workshop, administration, marketing and quality assurance organisations.

The shop supervisor, who is an engineer, is the head of the workshop. The workshop is divided according to types of manufacturing/reconditioning processes (layout by process): punching, welding, grinding, turning and milling, and heat treatment. This type of layout is common in job shop production facilities. Some of the advantages of layout by process are:

(1) Flexibility of equipment and personnel.

(2) Smaller investment in equipment because duplication is not necessary unless volume is large.

(3) Expertise: supervisors for each department become highly knowledgeable about the functions under their direction.

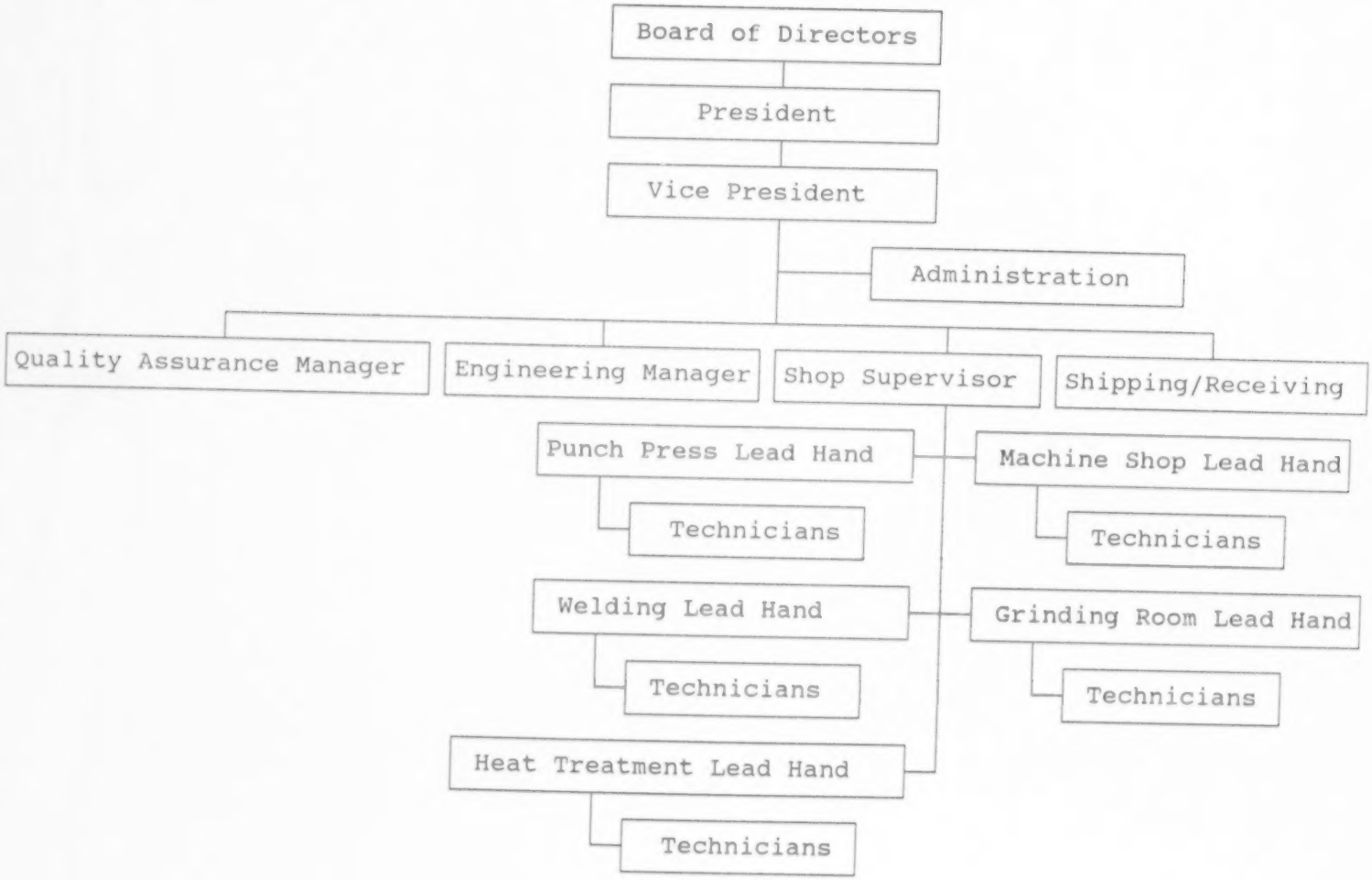
" MIG is acronym for Metal Inert Gas. This is an arc welding process that uses an arc between a continuous filler metal electrode and the weld pool. It is used with shielding from an external supplied gas and without application of pressure.

(4) Diversity tasks: work assignments make work more satisfying for people who prefer variety.

However, there are some negative considerations worthy of discussion: lack of efficiency in timing, lack of material handling efficiency and lowered productivity. Each job is different and requires different setups and operator learning.

It can be noted from the organization structure that there is no maintenance group. It was learned that STAMCO relies on external labour and contracts for maintenance of its machines. There is only one person who is dealing with maintenance, which involves mainly oiling and greasing. Together with the maintenance work, he performs other duties. The reason mentioned for not including maintenance in the organization structure is that machines do not break down often, and in the case of a breakdown, costs associated with it are estimated to be less than 10% of net income ($20,000). For this reason, stocking of spare parts has been avoided. The system of relying on external labour for maintenance works is effective only when one has an efficient means of obtaining spare parts. For example, a nearby spare parts store and payments by credit.

Figure 6-1: STAMCO Organization Structure



The system of relying on external labour and contracts for maintenance of machines may not be suitable to Tanzanian workshops for the following reasons:

(a) It may be difficult for contractors to arrange and carry out maintenance work promptly due to unavailability of parts and tools locally.

(b) Because of an availability of a cheap labour, contractors may be more expensive than employing internal maintenance personnel.

(c) Due to lack of technical documents, it may be difficult for contractors to repair/service machines effectively. Though the technical documents may be successfully formulated, they may require substantial resources which will add extra costs to the maintenance budget.

(d) The possibility that workers will feel that they are not trusted in maintaining their machines may have negative affect on morale. Though this is not an economic reason, it should be approached very carefully by incorporating workers in discussions before the final decision is made, as it may ultimately affect economics.

6.2.3 Types of Manufacturing:

STAMCO has adopted an intermittent type of manufacturing. Identification tags are produced in batches of 20,000 to 30,000 pieces, and stocked ready for prompt supply to

customers. This utilizes the advantage of economic lot size, and thus low manufacturing costs. Furthermore, though market growth for identification tags is low, the company has a high market share, and thus reliable cash flow.

Job-lot manufacture (production according to customer's purchase order or specification) is adopted in manufacturing of molds, dies and various industrial spare parts. A customer may order one, two, or more units of the product; a manufacturing order is entered for that lot only, material is procured, the units produced and shipped.

In Tanzanian workshops, job-lot manufacture is predominant. A customer places an order, and production commences after partial or full payment has been made. Workshops attempt to stock some raw materials in order to have them ready when they may be required. The observed problem with job-lot manufacture is that manufacturing costs are high. For example, a standard bolt which can be produced cheaply in large quantities, will be more expensive if produced in small quantities.

6.2.3.1 Work Order System:

As mentioned earlier in (section 6.2.3), the company depends on customer orders before production. The customer's instructions and other production controls are documented on

a work order card. A work order system comprises a job card in which information about the customer, delivery and job instructions, labour and materials used are recorded. See Figures 6-2 and 6-3.

A work order has four copies: first: for controller; Second: packing slip; third: internal record and fourth: a hard cover for shop control. All the information is entered into a computer. At the back of a hard cover, the name of the person and machine involved in production, and time spent are recorded for time control and planning. (See Figure 6-4).

Work order information, if documented properly, may provide the following benefits:

1) Job instructions: may be used for similar jobs in the future.
2) Labour and materials: may simplify cost estimation in case of repeat orders. In case of storage of raw materials, this may guide how much to stock.
3) Machine and time spent: knowing when the machine is busy, may help in production planning and time control.

Date ....., 19.... Job Card No. .....

STAMCO

PH. 436-2647
Specialty Tool & Mfg. Co. (1979) Ltd. FAX 436-7198
6048-97 STREET EDMONTON, ALBERTA T6E 3J4

Customer.....

Address.....

.....

Name ..... Phone .....

Order No. ..... STL.....

Delivery Instructions.....

Job Instructions.....

.....

.....

.....

.....

.....

.....

.....
Labour
.....
Matls.
.....
Net
.....
F.S.T.
.....
TOTAL

Figure 6-2: STAMCO's Job Card - Top/Hard cover

Date ....., 19.... Job Card No. .....

STAMCO

PH. 436-2647
Specialty Tool & Mfg. Co. (1979) Ltd. FAX 436-7198
6048-97 STREET EDMONTON, ALBERTA T6E 3J4

Customer.....

Address.....

.....

Name ..... Phone .....

Order No. ..... STL.....

Delivery Instructions.....

Job Instructions.....

.....

.....

.....

.....

.....

.....

Figure 6-3: STAMCO's Job Card - 2nd/3rd copy

NAME	MACHINE	TIME SPENT		CLOCK RECORD
		START		
		STOP		
		START		
		STOP		
		START		
		STOP		
		START		
		STOP		
		START		
		STOP		
		START		
		STOP		
		START		
		STOP		
		START		
		STOP		
		START		
		STOP		
		START		
		STOP		
TOTAL TIME ———				

Figure 6-4: STAMCO's Job Card - Time sheet

The importance of proper record keeping is overlooked in many Tanzanian workshops. As discussed earlier in (section 5.10.2), the work order system in Tanzania is not well designed: important information such as machine used, actual time used and person engaged in a particular job are neglected. As a result, the manpower is not well-utilized, repeat orders are not easily recognized, and production planning is difficult.

6.2.4 Maintenance:

STAMCO does not have a maintenance group in-house. It depends on external labour and contracts for repair of its machines. In 1990, STAMCO spent about $25,000 on maintenance of machinery and equipment. This is about 1.25 percent of the company's sales in 1990.

Table 6-1 shows some of the calculated maintenance indicators. The cost indicators are based on data reported by the workshop supervisor, and are for the year 1990.

6.2.4.1 Maintenance System:

According to Table 6-1, STAMCO uses a breakdown maintenance system (machines are repaired whenever they break down). Preventive maintenance is virtually absent. Figure 6-5 is a diagram of the various forms of maintenance. Breakdown maintenance may either be planned or unplanned: if carried

out on an emergency basis work can be categorized as unplanned, otherwise it is planned.

Table: 6-1 Maintenance Cost Indicators (in percentage)

Item	
1) Maintenance cost as percentage of sales value	1.25
2) Maintenance cost allocations	
External labour & contracts	72
Materials	28
3) Maintenance labour allocations	
Plant and equipment	24
Building	NA
Capital projects	76
4) Maintenance personnel as percentage of total employees	3
5) Maintenance cost as percentage of net income	12.5
6) Division of maintenance cost into:	
i) Planned work	0.5
ii) Breakdown work	99.5

6.2.5 Marketing of Spare Parts:

STAMCO employs a combination of production to customer order and to stock. This provides an assortment of products to market, and furthermore, less risk in a period of recession or depression. Products to stock include a variety of identification tags, hinges and other small parts. These products are simple and standardized, which are important

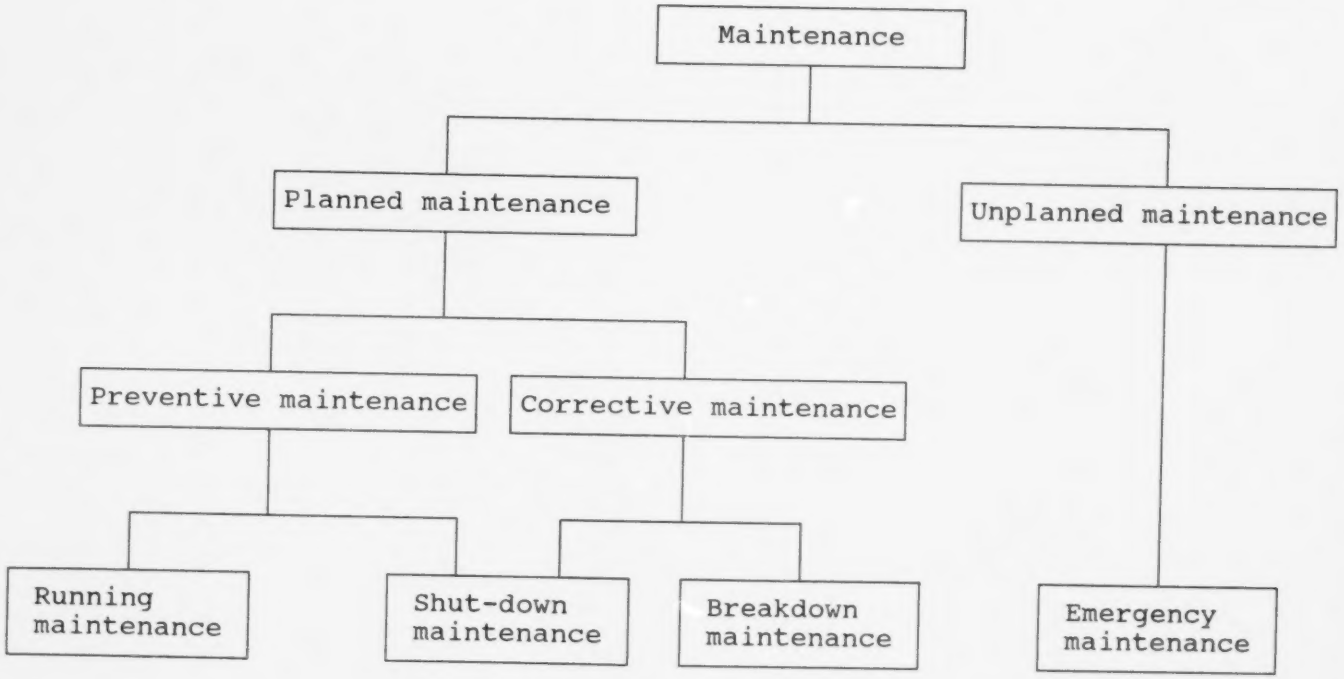


Figure 6-4: Major divisions of maintenance

aspects of meeting customer needs, as well as reducing costs of manufacture.

Production to stock has the following advantages:

a) offers a better service in terms of availability

b) increases market share

c) stabilizes production (economies of scale)

d) maintains economic order quantity

e) smooths production planning.

Reasons a) and b) are very important for competitive marketing.

Production to customer order is preferred for the following reasons:

a) product design flexibility to customers

b) minimizes risks of carrying inventories

c) closer control of quality

d) cost/price is a lesser consideration

e) lesser possibility of product obsolescence

Reason d) provides an opportunity of making high profit margins. This is supported by the high income ratio (net income/sales) as per 1990, which was 10 percent.

An important lesson to learn from the STAMCO's marketing strategies is that not only do they manufacture customer order products, but also a variety of standard products

which are fast moving. Most of Tanzania's workshops depend on customer orders which are not constant resulting in some periods where very little work is available and other times when they are quite busy. Product planning is a necessary activity for the long-run success of the business.

7.0 Conclusions and Recommendations

7.1 Summary and Conclusions:

The problem of spare parts has been experienced throughout the post Arusha Declaration (1967) period. It was mentioned as one of the problems causing capacity under-utilization in the economy. During the 1980's many companies operated below their installed capacities because machines were not available. A lack of spare parts is reported as a cause of low availability of machines. In the background information (section 1.2), the following observations were made:

a) Machine availability is a major problem because they are broken down and are not repaired due to unavailability of spare parts,

(b) Spare parts are not available because they have to be imported but the lack of foreign exchange hampers the importation,

(c) Local manufacturing of spare parts is deterred by lack of skills, raw material difficulties, quality problems, and tools shortage.

(d) Industrial maintenance is not well-managed.

The analysis of the survey data shows that availability of spare parts is a major problem and its causes are as follows:

- lack of raw materials
- lack of manufacturing technology and equipment

- lack of foreign exchange and long import system
- lack of skilled technical manpower
- lack of funds for procurement of parts locally
- lack of understanding of maintenance management
- no records or procedures
- inadequate maintenance practices
- unfavourable inventory management
- unfavourable market strategies
- preference of OEM parts over locally produced parts
- lack of tools, drawings and measuring equipment

It was observed that the local capability of manufacturing spare parts is not fully utilized. According to MEIDA studies in local production of spare parts, only a few "good" workshops are available. Workshops such as National Bicycle Company (NABICO), Cortex Metals, Institute of Production Innovations (IPI) and Tanzania Zambia Railways (TAZARA) are good workshops. Some spare parts currently imported can be successfully manufactured locally. This was demonstrated by MEIDA's study in local spare parts production (in section 5.5), where the involved workshops received orders beyond their production capacities. But the workshops were unable to fill this potential. The perceived problems included unavailability of proper raw materials, equipment and finances. One reason why they are still imported is that many people prefer OEM parts over local

produced parts. This preference for imports is because local producers are not reliable in terms of quantity or quality.

A lack of good marketing strategies further hampers production of spare parts. Industries and manufacturing workshops are not well coordinated. It is difficult to know who, where and what services may be available. Many workshops were originally designed to serve their companies, mainly as maintenance and repair workshops. Therefore, it will be difficult for them to assume competitive marketing unless a dramatic change in business structure is carried out. Market research is relatively a new phenomenon. Thus, wants and needs of clients are rarely known.

The problem of availability of raw materials (steels, brass/bronze, etc) is attributed to lack of foreign exchange. Most raw materials are imported into the country, either by industries themselves or agents. National Steels Corporation (NSC), the national supplier of steels, depends on the federal bank for obtaining foreign exchange which could be used for importation of raw materials. But the bank does not have sufficient foreign exchange to finance NSC's imports. Thus, a shortage of foreign exchange impedes NSC's operations. Unless it finds means of obtaining adequate foreign exchange for raw materials, it cannot effectively

supply adequate steels to workshops. It was observed that steels are available from private vendors at high prices, which in-turn add costs to the manufactured parts.

The problem of availability of foreign exchange is nation wide. Tanzania does not earn enough foreign exchange to pay for imports. Thus, the Government controls the use of foreign reserves, and provides it to industries according to its priorities. It was also noted that the exchange rate is controlled by the government and the Tanzanian Shilling is likely over-valued, leading to excess demand for foreign exchange.

Industries are encouraged to export more products in order to earn foreign exchange which could be used for the import of raw materials, spare parts and machinery. However, the export industries are still at the infant stage. The country relies mainly on agricultural and mineral exports for earning the badly needed foreign exchange. Bad weather sometimes hampers production of staple food crops, and the Government is forced to spend massive amounts of foreign exchange to procure foods. This causes a reduction in available funds for procurement of spare parts, machinery and raw materials.

The bureaucratic import system was observed to be ineffective: the bank procedure for obtaining foreign exchange was the most time consuming, and one is never sure whether he/she will be granted the funds. Normally a company has to secure an Import License (IL) before applying for foreign exchange and the IL is approved subjected to availability of foreign exchange. Thus it takes a long time to order raw materials or parts from abroad. The average lead time as reported by the maintenance managers is eight months.

Another problem which hampers manufacturing of spare parts is availability of manufacturing technology such as: bearings, intricate casted parts, some moulds and dies, electrical boards and various machinery parts. Many maintenance managers are of the opinion that they should import the technology in order to manufacture many parts locally. However, there is no evidence supporting the idea of importing technology rather than continuing to import the parts.

The importing of technology should be considered after solving some of the local spare parts manufacturing problems. There is presently a lack of raw materials, equipment and skilled technical personnel. All of these factors contribute to poor quality. Without solving these

problems, the importing of technology is likely to deepen the problem of spare parts manufacture.

Availability of spare parts manufacturing equipment varied from one workshop to another. Generally many workshops have invested in conventional machine tools and it is hoped that if a certain machine is not available in one shop it can be found in another shop. It is assumed that the workshops can cooperate and make efficient use of the available machinery and equipment. However, many maintenance managers perceived that investment in modern machine tools and equipment will have an important contribution to the on-going production of spare parts.

There is lack of working tools, measuring equipment and some parts do not have engineering drawings. These types of tools and equipment are scarce in the local hardware stores and due to high demand, prices are so high that it is difficult for management to provide them adequately.

The skilled manpower problem is definitely not insurmountable. Training programmes for technical skills within the country and abroad are feasible. The level of development determines the level of skills required and available within a country. Since development is a dynamic process, so is skill acquisition. Tanzania is currently not

in a serious situation, though it is unlikely that it will be self-sufficient in the near future. The observed problem is that the few available engineers are typically under-utilized, under-paid and poorly motivated.

There are some other problems which are attributed to the scarcity of spare parts. These problems are such as lack of standardization, inadequate maintenance practices and poor management of spare parts. Lack of standardization of spare parts is partly caused by varied types and brands of machines and different dimension scales. This adds inventory costs because many stocks can be reduced by standardization.

Old machines are related to a high rate of spare parts consumption. This suggests that either maintenance procedures are not properly executed or parts do not last. Parts do not last because the right raw materials are not available. So, spare parts are made of inferior materials which cannot be heat treated to the required hardness. Poor spare parts tolerances was mentioned by some maintenance managers as one of the causes of frequent parts failure.

Maintenance practices in many shops are carried out haphazardly. The existing machine tools are in poor condition because of inadequate maintenance and repairs.

Maintenance systems, however substantiated, are not followed because of lack of spare parts and management support. The questionnaire result shows that maintenance records are not adequate. The assessment of maintenance effectiveness, and planning cannot be done without adequate records.

There is mismanagement of available spare parts. Many stores are operated by unqualified personnel. As a result, transactions are inadequately recorded and orders do not arrive in time. Inventory lost due to obsolescence, damage and deterioration is generally minimum because of a relatively low volume of stocks.

It was observed that many industries cannot obtain spare parts from manufacturers. Some suppliers no longer exist thus making it difficult to obtain some spare parts. These industries depend on local workshops and hardware stores. For this practice, it is difficult to maintain economical order quantity (EOQ) because of either high costs associated with customized orders or scarcity.

7.2 Recommendations:

7.2.1 Local Spare Parts Manufacturing:

To alleviate the problem of availability of spare parts in Tanzanian industries, it is recommended that more efforts be directed to acquiring spare parts locally. The study

revealed that there is a great potential to manufacture spare parts within the country. What is required is to find solutions to the problems hindering the local production of spare parts. One possible solution is to arrange a spare parts exhibition which will bring together manufacturers and industries (clients). This exhibition will have four principal objectives:

1) manufacturers will understand each other, and possibly establish technical cooperation,
2) industries will know from who and where they can receive certain technical services,
3) both parties also may learn from each other,
4) the possible financial assistance from the government must be determined.

It may be difficult to attract all industries because the seriousness of the spare parts problem is not equally perceived. But, if the objectives are well communicated, it will be successful. Therefore, the preparations should originate from a high level organisation - the Ministry of Industry and Trade.

At the exhibition, manufacturers may display some spare parts which they produce and clients may bring spare parts which need manufacturing. This will help manufacturers to determine what they can potentially manufacture and clients to understand those parts which can be manufactured locally.

Industries should advertise their spare parts requirements. Manufacturers/suppliers may bid to supply the company with the required spare parts for a particular period. This will encourage some suppliers to import spare parts and thus reduce dependence on the bank of Tanzania for foreign exchange availability. When manufacturers have received orders as a result of the advertisement, it will be important to examine if they can successfully manufacture the required parts. It is recommended that a study be undertaken to inventory all engineering workshops in the country, and indicate their capabilities. In addition to this study, market research to determine the amount and type of spare parts required and the expected market growth is desirable. After determining those spare parts which can be manufactured locally (considering factors such as technology, equipment, technical skills and raw materials), they may be distributed among the manufacturers. This is important because it may require a manufacturer to invest in additional equipment, so market stability is essential. For example, NECO is contracted to supply original parts for Tanzania Automobile Manufacturing Company (TAMCO) and Valmet tractors for a long term.

It is anticipated that the problem of payment for ordered parts as experienced during MEIDA's study will exist. The

suggested solution for this problem is for the Government to provide help by financing the ordered parts.

As availability of raw materials, tools and measuring equipment will influence any attempt to manufacture spare parts, it should be of a high priority to ensure that they are easily available to spare parts manufacturers. The Ministry of Industry and Trade, in collaboration with suppliers and industries should cooperate and establish those items to be imported. The role of the Government is to provide the necessary help which may be required during the implementation.

Lack of modern machine tools and heat treatment facilities was mentioned by some companies. It was learned that most machinery and equipment required for manufacturing spare parts are within the country but access is a problem. However, the suggested solution is for those without sufficient equipment to use the services of those which have facilities. In addition, it is essential to conduct a study of existing machine tools in the country - their number, quality, age and type in order determine types of machine tools that should be imported for future expansion. This would complement the workshop inventory recommended above. The objective in this instance being on planning for future requirements.

The local manufacturers should improve the quality of their spare parts in order to convince people that their parts are as reliable as imported parts. Successful quality control involves inspections throughout the manufacturing processes and feedback from the user regarding suitability of a product.

Another possible solution of improving the local spare parts manufacturing is the formation of multi-purpose workshops. These workshops together with the existing workshops will render technical services to industries. The workshop model (appendix III) may provide more information on the implementation.

7.2.2 Maintenance Practices:

A possible means of reducing machine breakdown frequency and hence reduced spare parts consumption is by employing PM systems. There is a need to make dramatic changes in existing maintenance practices. The following lines of action should be taken:

i) The traditional way of handling maintenance by depending completely on repair operations is not a successful way to deal with maintenance problems. Tanzanian industries should adopt a PM type of maintenance techniques such as condition monitoring and regular shut-down maintenance.

ii) Promote and support the establishment of adequate record keeping and efficient costing systems in industrial enterprises. Adequate records guide maintenance managers in deciding on the proper balance between investment in production equipment and in maintenance facilities. Also, they enable managers to control and improve maintenance and production costs and performance, and evaluate the correct balance between preventive maintenance and repair activities.

iii) The unfavourable maintenance practices such as cannibalization of equipment as a means of handling maintenance and repair problems should not be encouraged. Should it be necessary to cannibalize, the cannibalized part should be replaced as soon as it is available. Such practices waste capital, which is usually scarce in the country.

iv) The entrepreneurs should study the possibility of establishing more central workshops in order to ease the load on individual enterprises and make maintenance and repair work more economical for them.

v) Establish a maintenance organization which will deal with maintenance promotion. It is suggested that it be

a voluntary Society of Tanzanian Maintenance Engineers (STME). The STME should look at education, standards and sharing experiences in maintenance. It will coordinate with other technical societies and institutions (e.g. the Institute of Engineers (IE), Tanzania Industrial Studies Company and Consultant Organization (TISCO), etc) to solve maintenance problems (spare parts, maintenance terminology, training, etc). Tanzania must develop indigenous solutions by sharing information and experiences. Also, establishing better contact with technical societies in industrialized countries interested in maintenance, will improve the flow of information regarding maintenance.

The maintenance engineers should meet at regular intervals. The current system of seminars does not provide adequate interactions among maintenance engineers. Seminars are conducted occasionally but are not followed-up making them less effective.

7.2.3 Import System:

The existing bureaucratic import system should be streamlined. After an order has been approved by the Ministry of Industry and Trade, the federal bank should

process it efficiently. This can be achieved by setting deadlines and monitoring.

7.2.4 Skilled Manpower:

Lack of engineers nationwide is not a serious problem. But the observed problem in some companies which do not have enough engineers may be a lack of motivation. Tanzanian engineers are often under-utilized and/or under-paid. It is suggested that the companies should provide salaries equivalent to the engineer's contributions. They should be given responsible positions in the organizational structure of enterprises. In addition to their normal duties, they can be utilized for training the artisans through evening classes. Since the training is conducted after normal working hours, as an incentive, they can be provided with special allowances. This will help to raise their earnings.

The artisan curriculum should be re-structured in order to accommodate courses in machine tool maintenance. This will allow them to understand better the machines which they are working with daily.

Efforts should be made to upgrade the skills of maintenance personnel at all levels. Meida Maintenance Services (MMS) offers various training in industrial maintenance management

at all levels. Efforts should be made to take advantage of this service.

7.2.5 Observations From the STAMCO Study:

The STAMCO study presented some useful ideas which may be applied to Tanzania's spare parts manufacturers. Manufacturing of standard parts is important for increasing market share. It is recommended that Tanzanian workshops should work toward including some standard parts in their products. Some of STAMCO's machine tools are as old as Tanzania's but they operate very well. If machine tools are effectively maintained, they can operate for many years.

It was also obvious from STAMCO's maintenance practices that some of the first world practices are not applicable to third world countries. STAMCO normally repairs on breakdown and utilizes maintenance contractors to repair and service its machines. This reliance on contractors is not currently likely to be suitable for Tanzanian industry because of constraints in obtaining spare parts and tools.

It is realised that it is indeed an easy task to criticise but a very difficult task to either improve or formulate solutions to shortcomings. However, it is toward this end that the present study has tried to make a contribution.

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APPENDICES

Appendix I

A Sample of Survey Questionnaire

U N I V E R S I T Y O F A L B E R T A

STUDY OF INDUSTRIAL SPARE PARTS INVENTORY IN TANZANIA

QUESTIONNAIRE

1. Name of a person filling the questionnaire:
2. Position:
3. Name of establishment:
4. When was it established?
5. Postal address

   Telephone number

   Location: City Region:

6. Number of employees:
7. What industrial category does your company belong? (e.g Engineering, Chemical industry, etc)
8. What are your main products/Services?
9. What is the estimated annual sales or annual production?
10. Do you export some of your products? Yes No
    If Yes, please list the products and countries you export to.

11. At what capacity is your company working presently?

12. What is the installed working capacity?

13. Do you often meet your performance targets? Yes No

14. Indicate reasons which may cause target shortfall

15. Is any of the following a problem to your company operations?

a). Lack of spare parts	Yes	No
b). Age of machinery and Equipment	Yes	No
c). Water shortage	Yes	No
d). lack of modern technology	Yes	No
e). Raw materials	Yes	No
f). Electricity shortage	Yes	No
g). Frequent machine breakdown	Yes	No
h). Poor Sales volume	Yes	No
i). Inexperience of personnel	Yes	No

16. Rank the top five of the above problems in order from worst to best.

17. Are there problems with spare parts? Please list the three main ones.

18. Please suggest solutions to the problems you have mentioned above.

19. Do you agree that spare parts consumption depends on the quality of maintenance work?

    Disagree Least Agree Agree Strongly Agree

20. The age of machinery and equipment is related to high spare parts consumption. Do you agree?

    Disagree Least Agree Agree Strongly Agree

21. Does Inventory Management influence the availability of spare parts in your company. Do you agree?

    Disagree Least Agree Agree Strongly Agreee

22. Do you still obtain spare parts required for your machines from manufacturers? Yes No

    If the answer is No, Please indicate where you get them.

23. What percentage of annual spare parts requirements can you obtain locally?

24. Please comment on the capabilities of your workshop:

    a). Operations

    b). Types of spare parts manufactured

    c). Capacity

25. What are the spare parts manufacturing problems in your workshop?

26. What in your opinion, could be the possible solutions to the above problems?

27. What types of raw materials are you using in the manufacturing of spare parts? Please specify, together with sources.
e.g. Steels: 1). Low carbon steel; National Steels
2). Gamma-Stainless steel; Imported, etc

28. What types of machine tools and equipment would you think, had they been available in your workshop could have enabled you to manufacture most of your spare parts requirements?

29. Please list some of the spare parts and manufacturing technologies involved, which you are importing from abroad?

30. Which technologies (mentioned above) are not available in the country (in Engineering workshops)?

31. Do you think that if those technologies are imported into the country, most of Industrial spare parts can be manufactured locally? Yes No If No, why?

32. What other factors do you think should be considered regarding spare parts manufacturing in the country?

33. What are the import procedures? Please explain from order processing up to receiving.

34. What is the average lead time for ordering spare parts from abroad? (From order preparation, secure funds from bank up to when you receive)

35. Do you think that something can be done to improve the existing ordering system? Please comment.

36. Do you have other sources of Foreign Exchange "FOREX" other than the Federal Bank?
Yes No If Yes, please specify.

37. What types of welding processes do you employ in your workshop?
Please specify; e.g. MIG, GMAW, TIG, etc.

38. What type and model of machine tools and equipment do you have in your workshop?

TYPE OF MACHINE OR EQUIPMENT	PROGRAMMING	AUT. TOOL ADJUSTMENT	EXTERNAL DATA I/O	SWING (MM)
e.g.				
1. Hitec-Turn	Fanuc 2 axes, Contouring.	Yes	No	450
2. HC400-40 Horizontal machining center	Fanuc UM-F 3 axes (x,y,z), Contouring.	Yes	Yes	NA

39. Please give a summary of your technical personnel in the maintenance department:

QUALIFICATION	NUMBER	
	Requirement	Available
Graduate Engineers.....		
Diploma holder Engineers.....		
Technicians.....		
Artisans.....		
Others (specify)		

40. How much do you spend annually on spare parts?

41. Total investment in equipment?

42. What percentage of your inventory is lost:

43. Do you have trained storekeeping personnel?
Yes No

44. Do you think that developing countries should acquire high technologies in manufacturing?

    Disagree Least Agree Agree Strongly Agree

45. Will the availability of spare parts and tools, hence improved maintenance systems help to improve productivity?

    Yes No

46. Any other relevant comments.

********** THANK YOU **********

A CASE STUDY OF STAMCO MACHINE SHOP.

1. Address Code:

   Telephone number

   Location: City Province:

2. When was it established?

3. Assets a) current (1990).
   b) fixed (machinery and equipment)

4. Number of employees:
   i) total direct labour
   ii) maintenance staff
   iii) All employees

5. Maintenance labour allocations of money (excluding cleaning and janitorial):
   i) plant & equipment
   ii) building
   iii) capital projects
   iv) services

6. What is the estimated annual sales or annual production?

7. Net income

8. What is annual maintenance cost?

9. Maintenance cost allocations:
   i) internal maintenance dept.
   ii) labour
   iii) materials
   iv) overhead charges

10. How much paid for external labour and contracts in maintenance?

11. Division of maintenance cost into:
    i) planned work
    ii) breakdown work
    iii) minor repairs
    iv) improvements etc.

12. At what capacity is your company working presently?

13. What is the installed working capacity?

14. Spare parts reconditioning techniques employed:

15. Types of maintenance system employed in plant?

16. Sample of maintenance work order systems:

17. Organization structure of the company:

18. Maintenance organization:

19. How do you market your spare parts?

20. How are maintenance stores organized.

21. Please comment on the capabilities of your workshop:

    a). Manufacturing processes:

    b). Types of spare parts manufactured:

    c). Capacity

22. Chart the work order system:

23. What types of welding processes do you employ in your workshop?
Please specify; e.g. MIG, GMAW, TIG, etc.

24. What type and model of machine tools and equipment do you have in your workshop?

TYPE OF MACHINE OR EQUIPMENT	PROGRAMMING	AUT. TOOL ADJUSTMENT	EXTERNAL DATA I/O	SWING (MM)
e.g.				
1. Hitec-Turn	Fanuc 2 axes, Contouring.	Yes	No	450
2. HC400-40 Horizontal machining center	Fanuc UM-F 3 axes (x,y,z), Contouring.	Yes	Yes	NA

25. Please give a summary of your technical personnel in the maintenance department:

QUALIFICATION	NUMBER	
	Requirement	Available
Graduate Engineers.....		
Diploma holder Engineers.....		
Technicians		
Artisans		
Others (specify)		

THANK YOU

Appendix II

MEIDA MAINTENANCE SERVICES (MMS) LTD

MMS offers both theoretical and practical services to the industries. The theoretical services include consultancy and training while the practical include reconditioning and repair of machines, components and spare parts, condition monitoring and cleaning of hydraulic and lubricant oils.

The aim of these services is to assist the industries to:

- Increase production
- Reduce frequency of breakdown
- Reduce spare parts consumption
- Reduce maintenance costs

MAINTENANCE CONSULTANCY

Maintenance consultancy is a service provided to industries with an aim of improving the overall maintenance performance. The area covered are:

I Maintenance Organization

II Maintenance Routines and System

III Maintenance Workshop

IV Spare Parts Management

CONDITION MONITORING SERVICES (CMS)

CM should be performed at regular intervals whereby visual inspections and measurements are carried out in order to

detect failures, to follow the development of failures and to take necessary actions.

Besides visual inspections and inspections using simple aids, the following instruments and aids are used for complete and objective inspections:

- **SHOCK PULSE METHOD** - For measurement of ball and roller bearings.
- **VIBRAMETER** - For measurement of vibration and unbalance.
- **ULTRASONIC LEAKAGE DETECTOR** - For detection of leakages of gas, steam and fluids.
- **ULTRASONIC THICKNESS MEASUREMENT** - For measuring thickness of materials and for detection of cracks.
- **CONTACT THERMOMETER** - For measurement of temperatures.
- **TEMPERATURE TAPES, CRAYONS** - For indication of temperature level.
- **STROBOSCOPE** - For visual inspections of moving parts during operations.
- **CRACK DETECTION** - For detection of surface cracks with magnet powder methods, ultra violet light method, and penetrating liquids.
- **TACHOMETER** - For measurement of revolutions, speeds etc.

- **STROBOSCOPE** - For detection of abnormal noise.
- **MOTOR CHECKER** - For measurement of electrical motors with respect to insulation and resistance in wiring and inductance.
- **OIL TESTING EQUIPMENT** - For testing of oil with respect to viscosity, contamination and water content.

The actual condition monitoring services can be done according to contract and at regular intervals by engineers and technicians in cooperation with maintenance personnel. Based on this an inspection report will be prepared containing a description on all detected faults and recommendations on actions to be taken to rectify them.

MAINTENANCE TRAINING (MT)

MT provides a means of upgrading the knowledge of maintenance personnel and thus improving the maintenance performance. The training can be tailor made covered specific needs of an industry or an open one dealing with the general topics maintenance. The topics covered are:

I Maintenance Overview

II Corrective and Preventive Maintenance

III Preventive Maintenance

IV Corrective Maintenance

V Spare Parts and Inventory Control

VI Condition Monitoring

RECONDITIONING AND REPAIR

Several machine parts and components in industries are scrapped due to minor defects or wear. Most of these components could be reconditioned and put back to service by using the following techniques which will be available:

I Metal Spraying (MS)

II Metal Plating

III Maintenance Welding

IV Metal Stitching

V In-situ Repair

APPENDIX III

III.0 A Model of a Machine Shop for Tanzanian Spare Parts Production.

III.1 Introduction:

Based upon the observations, interviews and experiences, a hypothetical model machine shop was devised. This machine shop model is designed to cater to the manufacture and reconditioning of a wide range of industrial spare parts. It is intended to be a central workshop which will serve several industries. Unlike most maintenance workshops in Tanzania, which are within manufacturing industries, this workshop will operate independently, and thus must be able to run profitably. The model incorporates various information gathered from this study, the author's experience in Tanzanian industry and equipment vendors. From the questionnaire results, problems related to unfavourable spare parts manufacturing and marketing practices were mentioned: thirty three percent lack raw materials (steels, brass, etc.), 33 percent lack modern technology, 25 percent indicated delay in supply of spare parts locally or from abroad (see Table 3-9). Furthermore, in Table 3-6, 42 percent indicated that they had problems in marketing their products.

In section 5.5, it was observed that most of the spare parts manufacturers are not conversant with serial production, and the major cause is inappropriate machines. Specialized machine tools would be required for specialized jobs. For example, STAMCO has invested in an electrical discharge machining facility, which is specialized for die and mould production. The die and mould work could be manufactured by using other conventional machine tools, but production costs would be higher. In Tanzania's situation, most machine shops are equipped with manual operated machine tools and it is difficult to handle batch production efficiently.

In the questionnaire results, Kilongo* suggested that the establishment of specialised workshops will improve the production of spare parts. This idea focuses on joint efforts between the Government and industries. From the current foreign exchange situation, it is evident that not all industries are capable of owning modern machine tools. Even if this is possible, their effective application and utilisation may be a concern. Modern machine tools have high capital costs and if their capacities are not utilized, it may adversely affect the profit of the company.

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* Kilongo, maintenance manager of BORA company, when asked to suggest solutions to the problems caused spare parts shortages, he said; "In collaboration with manufacturers and suppliers, the Government and spare parts consumers should help to form specialized firms for producing spare parts".

Therefore, existing machine tools should be utilized effectively before modern ones are imported.

As mentioned earlier, Tanzanian workshops are facing problems related to marketing their spare parts. This may be caused by:

(a) many companies manufacturing the same type of product,

(b) reduction in demand due to a changing pattern of trade,

(c) lack of managerial competence and

(d) lack of advertisement.

Furthermore, in a detailed analysis of the spare parts manufacturing in Tanzania, it was revealed that most of the workshops were established to provide support to maintenance departments. They were not designed to service outside industries. For this reason, their business structures do not conform to a new extended task of servicing other industries.

As mentioned in section 6.2.3, most of Tanzania's workshops adopt a job-lot type of manufacturing. They only depend on customer's orders; it was learned from STAMCO that a product portfolio is very important for effective marketing. The product portfolio provides an assortment of products and

further, less risk of cash flow shortages. Figure III-1 shows a product portfolio in different quadrants [26].

The objectives of product A "star" are:

a) increase market share and

b) potential of high market growth.

Though cash is required to maintain its position, its contribution to the company's economy is substantial. Product D "cash cow" is of low market growth but high market share. Thus, increased cash flow to the company. Its objective is to reduce costs. For example, batch produced products which are marketed in large volumes.

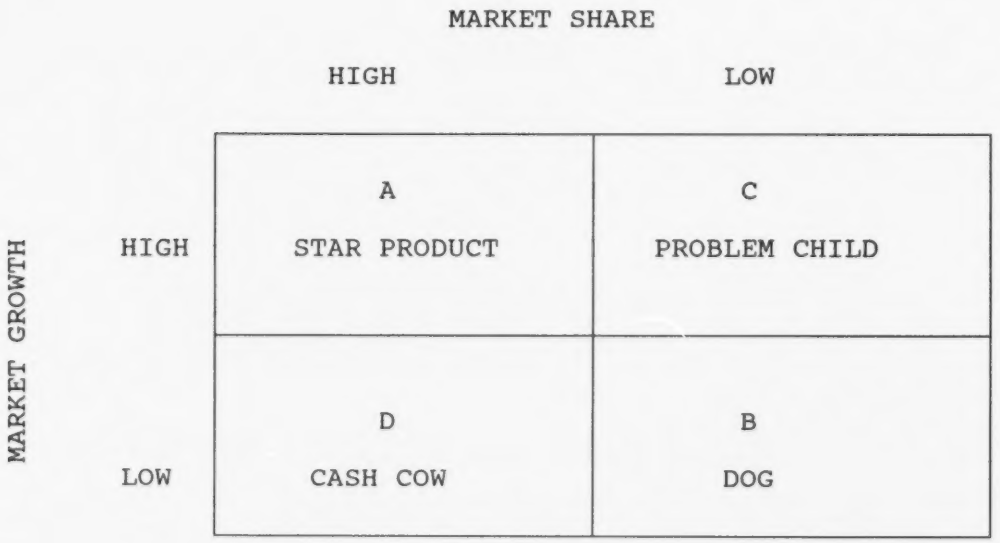


Figure III-1: A product Portfolio quadrant

Other products include C "problem child" and B "dog". Product C has the potential of becoming a star if more efforts are devoted in market research. But B "dog" should be discontinued and replaced by a new product.

As mentioned in Chapter 5, Tanzania's industries employ inadequate maintenance practices. In order for the intended machine shop model to work properly, a well organized maintenance system must be instituted and followed. It is obvious that the purpose of maintenance is to increase the lifetime of machines and to prevent breakdowns that slow or stop production. In order to accomplish this, a maintenance system should be formed and be responsible for the execution of the installed system. STAMCO's maintenance system, subcontracting virtually all maintenance activities works fine for this company. However, for the Tanzanian situation, some perceived problems should be solved before recommending it. With improved availability of spare parts and tools, the workshop can extend its services to a maintenance contractor for the industries.

The scope of the design work falls naturally into three categories:

1) design and selection of machinery and equipment
2) machine shop layout
3) formulation of a maintenance organization

III.2 Limitations:

The design of the machine shop model, will be limited to information gathered in the study, STAMCO's experience and information from machinery vendors. The data collected in machine tools inventory in Tanzania is not adequate to assess the need of new machine tools. According to UNIDO studies, a record of machine tools should not only show the numbers, but also ages and their conditions [105]. The model will reflect current spare parts manufacturing problems in Tanzania: lack of modern facilities, difficulties in handling batch production, market strategies and maintenance problems.

The capital cost of the equipment, whenever available, will be accepted at face value and altered as new information is made available. But the cost will be kept as low as possible reflecting the economic situation of Tanzania. Technologically, the equipment should reflect factors such as scale of production, availability of skills for both production and maintenance, economic background, and local geographical conditions.

III.3 Selection of Machinery and Equipment:

Regardless of sizes and costs, machine tools can be categorized into five major classifications according to techniques of shaping metal:

i) drilling and boring (including reaming and tapping)

ii) turning

iii) planing and shaping (including broaching)

iv) milling

v) grinding (including honing).

In addition to these techniques, there are other machining processes that employ the disintegrating, corrosion, erosion, and force characteristics of chemicals, electricity, magnetism, liquids, explosives, sound, and light. Some machines combine two or more of these techniques; a lathe machine can perform turning, drilling, boring, threading, tapering and facing. However, there are some factors which determine what machine tool should be used for a certain job such as the size and shape of the work piece, tolerances and surface finish desired.

In the questionnaire analysis (Chapter 4), the problem of unfavourable machine tools was mentioned. Most of Tanzanian workshops do not have suitable machines for the manufacturing of a variety of spare parts. As a result, the production time is unnecessarily long, and in some cases, it may be difficult to attain desired tolerances.

Table 3-20 shows some spare parts currently imported into the country and production technologies. Further, Table 3-21 shows a list of technologies not available in Tanzania.

Despite a few specialized technologies such as bearings, hydraulic and pneumatic valves, electronic boards, and steam flexible pipes production, the other technologies are either casting, moulding or machining. The machining technology is the most common. It seems that, though most of Tanzania's workshops employ the five basic machining techniques, there may be shortages of certain machines. In the questionnaire results, it was learned that some spare parts could not be manufactured because of alignment problems. This may be due to lack of either suitable jigs and fixtures or machine tools.

Table 3-19 shows machine tools and equipment requirements as reported by industries interviewed. Machines such as the surface grinder, universal milling machine, radial drill, cylindrical grinder, broaching machine, gear hobbing machine and modern lathe were mentioned by most of the industries. Other facilities were heat treatment and metal casting. The NC/CNC machine tools were mentioned by a few industries.

One key intent of the model is to service industries in the country. These industries are of different categories, and thus, parts are quite diversified. With this in mind, surely services will be of a wide range. Most jobs will be customized (according to customer's orders). Thus, flexibility of machines is important in order to handle

orders as per customer needs and wants. It is anticipated that quantities will vary considerably. As the production volume of some parts will be quite substantial, this would entail a great deal of time on production if performed by conventional machines. Therefore, some machines selected should be able to handle batch production.

Table 3-15 shows some of the spare parts manufactured in some of Tanzania's industries. These include gears, shafts, casts and other generic parts. The three main technological processes involved are:

1) casting
2) welding
3) machining

From the information above, the following machine tools are proposed:

a) conventional lathe
b) universal milling machine
c) turret lathe
d) radial drill
e) surface grinder
f) cylindrical grinder
g) gear hobbing machine
h) NC milling machine
i) NC turning centre
j) shaping machine

The number of machines cannot be determined because of inadequate records. All the machines except the NC milling machine can be purchased locally from the Kilimanjaro Machine Tools Manufacturing Company (KMTMC). This alleviates the problem of obtaining foreign exchange. The costs of the NC milling and turning machines in 1991 range from $60,000 to $250,000. Costs for the rest can be obtained from the KMTMC. Other equipment would include a tool grinder, band saw and a tap disintegrator.

III.3.1 Welding Processes:

According to the questionnaire's analysis, the predominant welding processes are:

i) stick welding

ii) Oxy-acetylene gas welding

iii) soldering and brazing

All industries interviewed indicated that they employ these welding processes. With these common welding processes, it may be difficult to perform a wide range of welding jobs efficiently. The stick process may not produce a better weld than TIG due to the nature of its operations. Therefore, additional equipment together with the stick welding process are TIG and MIG. The common materials to be welded are: mild steels, alloy steels, stainless steel, aluminium alloys, copper alloys, cast iron and malleable irons.

Stick welding can join almost all the materials above, except copper alloys and is less effective for aluminium alloys [11]. But, the quality or reliability of the joint produced, may be of much concern. For this process, the quality of the weld depends on a number of variables such as a design of the joint, the electrode, the techniques used and the skill of the welder. The last variable (skill of operator), probably is the greatest handicap in this process.

Table 3-26 shows that only 13 percent of the questionnaire's respondents employ MIG welding. This process is very versatile for welding nonferrous metals; typical applications are the welding of aluminium, bronzes, copper and copper alloys. Other metals include stainless steel, cast iron, medium-carbon steel, magnesium, low-carbon steel and alloy steel. Unlike the stick welding process, the MIG process can produce extremely high quality welds. This is due to absence of hydrogen in the shielding gas atmosphere, slags and fluxes which might become entrapped in the weld.

Only 22 percent of Tanzania's industries employ Tungsten Inert Gas (TIG) welding processes for manufacturing and reconditioning of spare parts. This level of utilization is quite low. The observed problem is an inadequate training for operators. According to available literature, the

repair and maintenance industry is a major user [12]. TIG is used for repairing tools and dies, cast aluminium and magnesium parts, and highly critical items. Quality wise, this process ranks higher than any of the arc welding processes. This is important for welding high precision parts.

III.3.1.1 Welding Equipment:

Hobart Brothers Company offers a wide range of welding equipment. For TIG welding, the constant-current power source is used. A typical TIG welding machine operates with a range of 3 to 200 amperes or 5 to 300 amperes with a range of 10 to 35 volts at a 60 percent duty cycle [13]. Again, Hobart has a wide range of MIG welding equipment. The most popular equipment are of 300 and 500 amperes [14].

III.4 Layout of Facilities:

As mentioned earlier, the production will be according to customer's orders. The orders received are usually for small quantities, except for a few customers such as the TCMB, TAMCO and other large corporations which order some parts in large quantities. The vast majority of customers are small and medium size industries, and these individuals each come with different types or styles of spare parts. With this type of production, the process layout is suitable.

In a process layout, the type and operational characteristics of production equipment are the determining factors in the arrangement of the shop. There will be several distinct sections/departments such as machine and heat treatment departments. Further, within such departments, machines of similar work characteristics, (lathes, milling machines, drilling machine, and so on) are commonly grouped together.

The spare part is fabricated by moving it from department to department according to the sequence of operations to be performed. Process layout provides for great flexibility in output; a variety of spare parts can be produced with the same machines. This layout is common to most of Tanzania's workshops. But, the utilization differs from one workshop to another; some workshops do not have adequate machines. In Canada, the STAMCO workshop adapts the same system, and it marries with the current production system.

Figure III-2 shows STAMCO's shop layout. The machine room houses various machine tools such as lathes of different sizes, horizontal milling machine, universal milling machine, radial drilling machine and electrical discharge machining equipment. In the punch press room, there are several eccentric presses and one CNC milling machine.

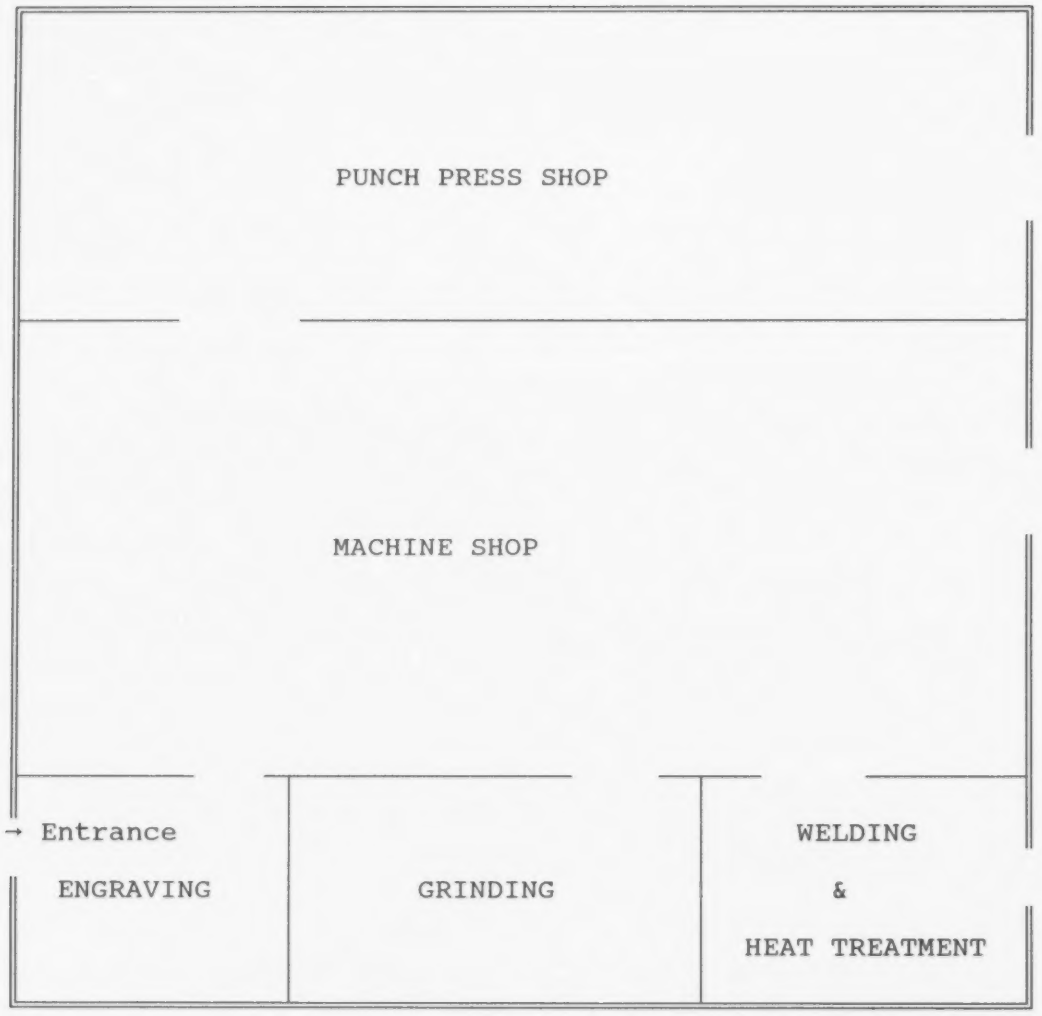


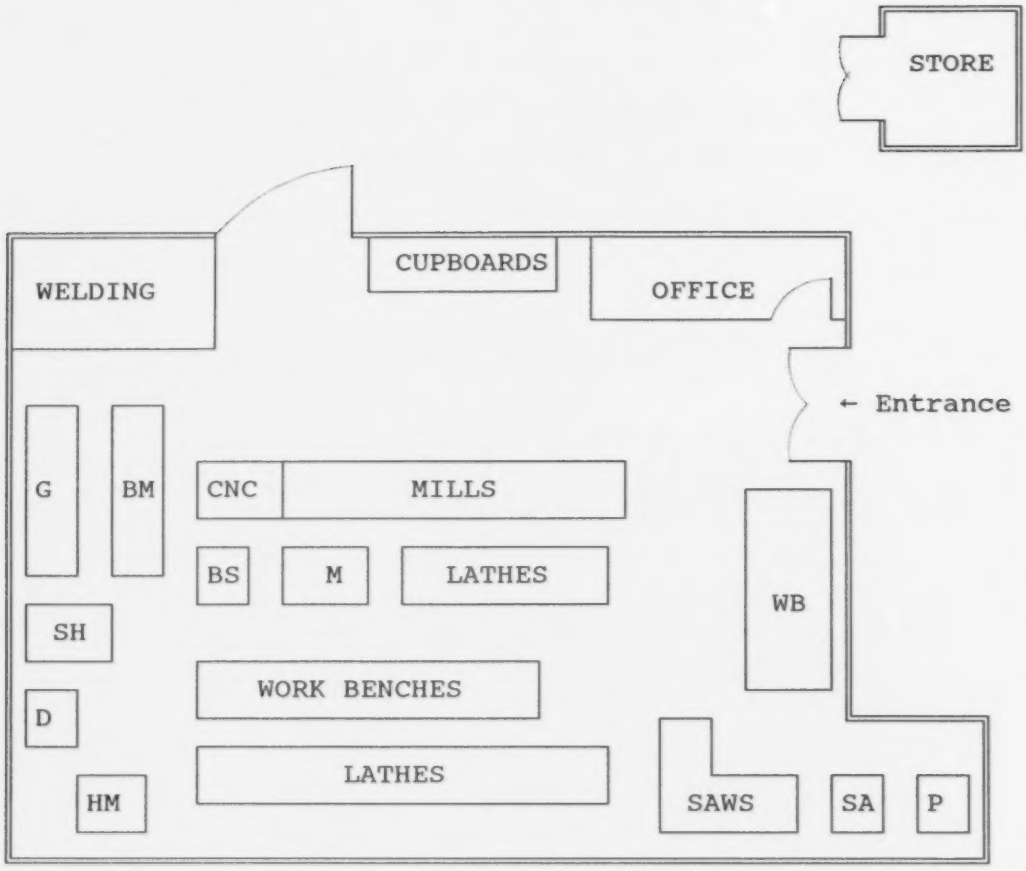
Figure iii-2: STAMCO Workshop Layout

Other rooms have equipment grouped according to their processes.

It is not clear why the CNC milling machine was placed in the punch press room. One would expect it to be installed in the machine shop because it can perform similar operations as other milling machines. However, this shop layout is a good example of a general purpose workshop.

Figure III-3 shows the University of Alberta (U of A), department of mechanical engineering machine shop layout. All machine tools, heat treatment and welding equipment are housed in the same room. But, related machines (those employ same processes) are grouped together, and the welding section, though not partitioned, is well separated from the rest of the shop. It can be observed that a raw materials store is located near the shop. One has to go outside the shop in order to collect raw materials. The location of the store may not be the best alternative because of a distance between it and the shop. However, it should be noted that a solution that is completely favourable in all ways is seldom reached.

The layout observed at the U of A, Mechanical Engineering shop, can be found in some Tanzania's shops. Figure III-4 shows CMB's Tanzania Limited machine shop. Machine tools are



LENGED:

BM	Bending Machines
BS	Band Saw
CNC	Computerized Numerical Control Milling Machine
D	Drills
G	Grinders
HM	Hobbing Machine
M	Mills
P	Planer
SA	Belt Sander
SH	Shaper
WB	Work Benches

Figure iii-3: University of Alberta - Workshop Layout

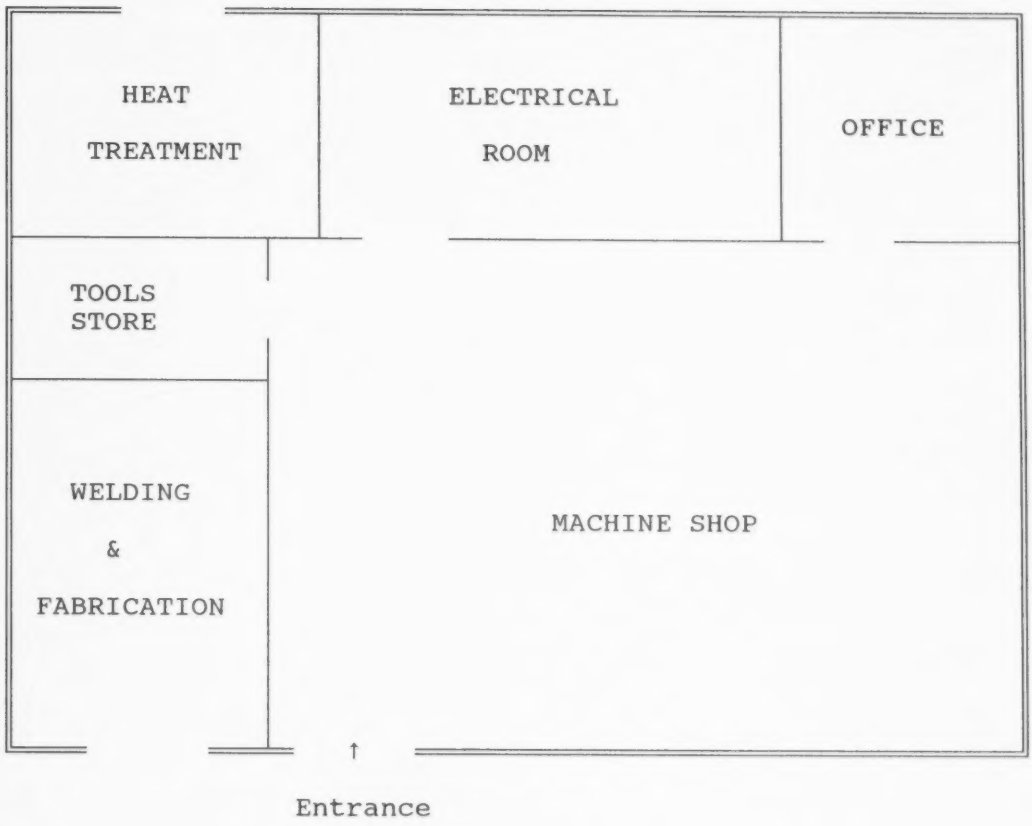


Figure iii-4: CMB Tanzania Limited - Workshop Layout

crowded in one room and in case of an accident, it may cause a serious injury. Distances separating the machines are short, and this may be attributed to smaller shop space; more machines were procured, but the space remained almost the same. Raw materials and spare parts stores are located more than 100 metres outside the shop. This is obviously not a good plan because of time lost in collecting parts and/or materials.

The primary goal of a shop layout is to maximize profits by arrangement of all shop facilities to the best advantage of people, materials, machines and money. According to Apple [2], a layout should be planned with the following objectives:

a) facilitate the manufacturing process
b) minimize material handling
c) maintain flexibility of arrangement and operation
d) hold down investment in equipment
e) make economical use of the building cube
f) promote effective utilization of manpower
g) provide for employee convenience, safety, and comfort in doing the work.

III.4.1 The Proposed Shop Layout:

Figure III-5 shows the proposed layout for a Tanzanian spare parts manufacturing and reconditioning workshop. All

machine tools except grinding machines will be located in the machine shop. Grinding machines are located in a room because of safety reasons and dust. Grinding wheels breaking into pieces which may cause injuries to nearby operators. A welding room is separated from the rest of the shop because of arc flashes and possible fumes which may have escaped from an exhaust hood. A heat treatment room will contain furnaces, hardness testing equipment, and other accessories. This layout was designed without adequate information. But, it is believed that if the data on the parts, volume, sequence, and parts per load is available, the optimum arrangement for the rooms can be determined.

III.5 Maintenance Organization:

As mentioned earlier (in section III.1), the machine shop model will have an in-house maintenance group. The scope of this section is to detail the important aspects for formation of planned maintenance. In Chapter 5 (in section 5.11 to 5.11.4), various maintenance problems in Tanzanian industries were analyzed, and possible handicaps pointed out. This maintenance model will take into consideration the perceived problems, and propose suitable system.

The introduction of most planned maintenance schemes is the result of a decision taken by higher management. It is understood that the initiative should originate at this

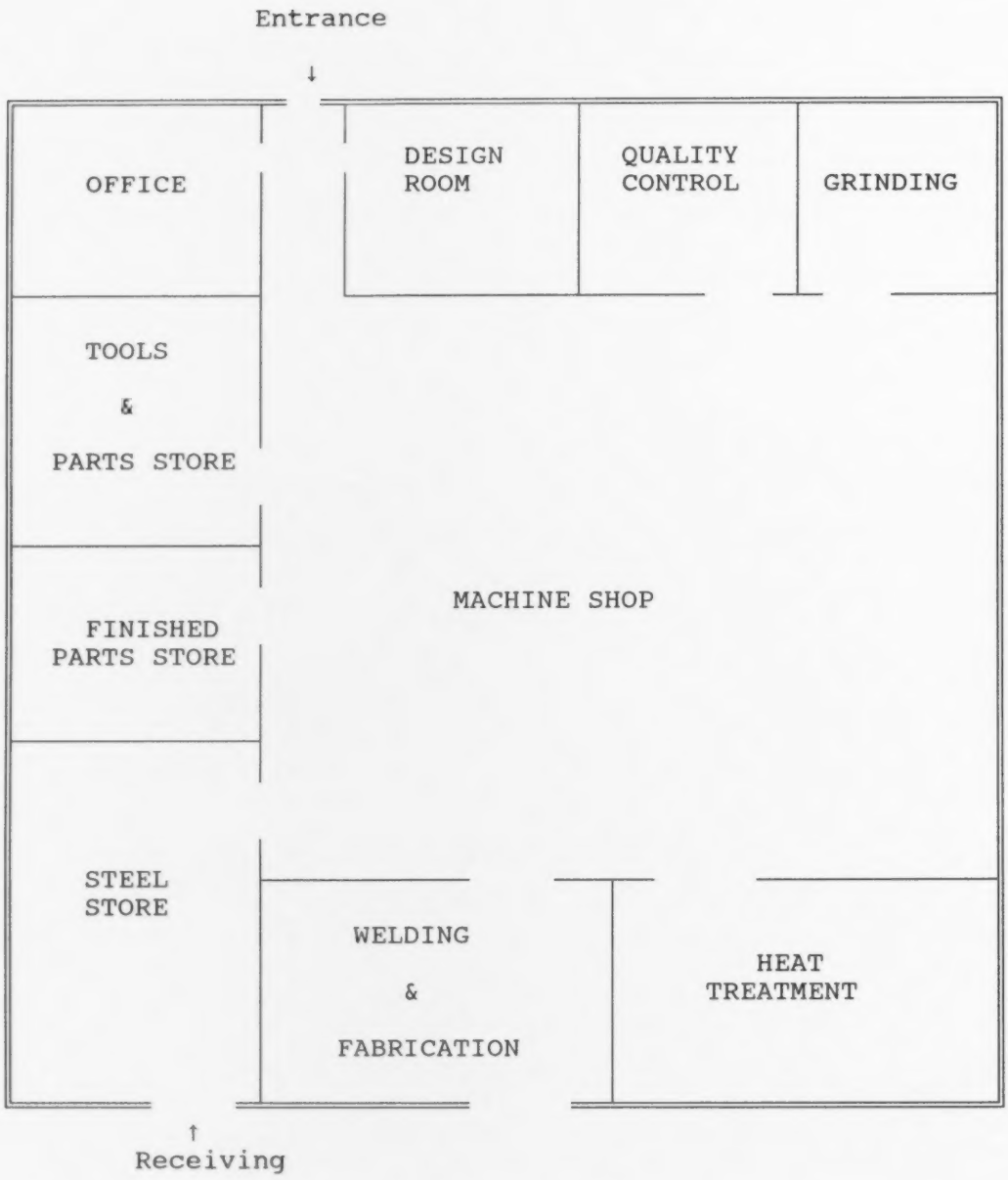


Figure iii-5: Proposed Workshop Layout for Tanzanian Industry

level. Not only must senior management actively promote and encourage new ideas, but also it is in a position to evaluate them and has necessary authority to see them through. So, in order to succeed, planned maintenance is recommended to start with the higher level management who know how important and costly it is, and evaluates it for the company application.

III.5.1 The Inventory:

Figure III-6 illustrates the form of an inventory sheet that would be suitable. The inventory sheet consists of the following:

i) identification symbol
ii) description of facility
iii) location
iv) type
v) priority rating
vi) remarks.

All facilities in the shop are listed for purposes of identification. This is necessary as it makes sure no machine is skipped when designing the planned maintenance.

III.5.1.1 Identification Symbol:

Each machine must possess a positive means of identification. Each identification symbol will be made up of a six digit number. Reading the number from left to

right:

- the first two digits indicate the location of the machine, e.g. machine shop.
- the next two digits indicate the type of the machine, e.g. lathe machine.
- the last two digits indicate the machine number within the shop.

The following is the key to the list of equipment:

01 milling machine	10 radial drilling machine
02 surface grinder	11 shaping machine
03 cylindrical grinder	12 gear hobbing machine
04 centre lathe	13 slotting machine
05 turret lathe	14 hydraulic press
06 NC turning centre	15 band saw
07 NC milling machine	16 electrical
08 vertical boring machine	17 TIG welding equipment
09 horning machine	18 MIG welding equipment

In similar procedures other machines can be allocated numbers.

The locations can be assigned number as following:

01 machine shop	04 welding and fabrication
02 grinding	05 steel store
03 heat treatment	06 design room

NAME OF COMPANY:

INVENTORY SHEET SHEET NO. .....

No.	ID SYMBOL	DESCRIPTION OF FACILITY	MODEL	PRIORITY RATING	SERIAL NUMBER	REMARKS
1	01-01-01	MILLING MACHINE				
2	02 02 01	SURFACE GRINDER				
3	02 03 01	CYLIND. GRINDER				
4	01 04 01	CENTRE LATHE				
5	01 05 01	TURRET LATHE				
6	01 06 01	NC TURNING CENTRE	N			
7	01 07 01	NC MILLING	N			
8	01 08 01	BORING MACHINE				
9	01 09 01	HORNING MACHINE				
10	01 10 01	RADIAL DRILL				
11	01 11 01	SHAPING MACHINE				
12	01 12 01	GEAR HOBBING				
13	01 13 01	SLOTTING MACHINE				
14	01 14 01	HYDRAULIC PRESS				
15	05 15 01	BAND SAW				
16	03 16 01	ELECTRIC FURNACE				
17	04 17 01	TIG EQUIPMENT				
18	04 18 01	MIG EQUIPMENT				
.						
.						
.						

Figure iii-6: Proposed Inventory Sheet

III.5.1.2 Description of Facility:

A brief description of the machine concerned; whenever possible, name plate details should be included.

III.5.1.3 Priority Rating:

This rating, in descending order ranging from 5 to 1, indicates the relative importance of a particular machine within the production process.

III.5.2 Facility Register Card:

Figure III-7 illustrates a facility register card for a centre lathe. Facility register cards for other machines can be formulated by using the same procedures.

Items that are to be included in the maintenance plan should be selected from the inventory sheet (see Figure III-6) and the **vital statistics** about each are entered in the facility register. The register card consists of the following:

- identification number
- type of facility
- manufacturer, date of manufacture
- serial number; specifications: size, model, etc.
- capacity; speed
- total weight
- power and service requirements
- connection details, installation specifications:

foundation, overall dimensions

- reference drawing number, and reference number of service manuals.

III.5.3 Maintenance Schedule:

Figure III-8 shows suggested maintenance schedules for milling, horning, centre lathe, surface grinder, shaper, boring and drilling machines. The maintenance schedule is a comprehensive list of maintenance and its incidence. Having gathered information on the physical characteristics of the equipment, it is necessary to establish *how it is to be maintained*, thus the importance of the maintenance schedule.

III.5.4 Maintenance Programme:

Having established the facility register card and the maintenance schedules which show *what* to be maintained, and *how* to be maintained, it is necessary to consider *when* it is to be maintained. The maintenance programme provides solutions by allocating a specific maintenance activity to a specific period.

Figure III-9 shows a typical maintenance program for machines that could be applicable to Tanzanian industries. The main purposes of the maintenance program are summarized as follows:

NAME OF COMPANY:		
F A C I L I T Y R E G I S T E R C A R D		
NAME OF MACHINE: *centre lathe*	CODE NO. *01 04 01*	ASSET NO.
MANUFACTURER:	SERIAL NUMBER	DATE OF MANUFACTURE:
SPECIFICATIONS:	MODEL NUMBER: *N*	GUARANTEE
OVERALL DIMENSIONS: L..... H ..... B	WEIGHT (kg)	FLOOR SPACE:

CENTRE - BED - SADDLE GAP DIMENSIONS	mm	SPINDLE, BEARINGS, PULLEY DIMENSIONS	mm
LENGTH OF BED		-HOLE THROUGH SPINDLE	
-ADMIT BETWEEN CENTRES		-FRONT SPINDLE BEARING:	
-SWING OVER BED		DIAMETER/WIDTH	
-SWING OVER SADDLE WITH		-BACK SPINDLE BEARING:	
TAPER TURNING		DIAMETER/WIDTH	
-SWING OVER SADDLE GAP		-DRIVING PULLEY:	
DIAMETER		DIAMETER/WIDTH	
-SWING OVER GAP WITH			
SCREW REMOVED			
-WIDTH ACROSS BEARINGS			
-DEPTH OF BED			
-LENGTH OF SADDLE			

SPEED/FEED	AUXILLIARY EQUIPMENT	OTHER DETAILS
SPINDLE SPEEDS: SPEED OF PULLEY: NUMBER OF FEEDS, ETC.	MOTOR: POWER: ..... PHASE: ..... VOLTAGE:	COOLANT: LUBRICANT: DRAWING NO: MANUALS NO:

Legend: B breadth H height L length N new

Figure iii-7: Proposed Facility Register Card.

NAME OF COMPANY:

M A I N T E N A N C E S C H E D U L E

MACHINE CODE NO. 01 04 01 | NAME: CENTRE LATHE | FILE NO.

JOB DESCRIPTION	DATE	AVAILABLE FOR MAINT	TIME REQU	WHO REQD TO RESTORE	LUBRICANT TOOLS	MECHANIC	WORKING FOREMEN	REMARKS
DAILY - SERVICE								
-check oil level in sump,								
fill if necessary		S		AR	CAN			
-check pump working								
through sightglass		R		AR				
WEEKLY - SERVICE								
-oil moving parts		S		AR	CAN			
MONTHLY - SERVICE								
-check clutch adjust if								
necessary		S		AR	G			
-check, tighten nuts		S		AR	TW			
-check wear of lead screw		S		AR				
-check belt tension and								
adjust if necessary		S		AR	SP			
3 MONTH - SERVICE								
-check speeds & feeds;								
note peculiar noises		R		AR	TM			
-open head stock cover;								
check oil distribution								

Figure iii-8 (Continued)

JOB DESCRIPTION	DATE	AVAILABLE FOR MAINT	TIME REQU	WHO REQD TO RESTORE	LUBRICANT TOOLS	MECHANIC	WORKING FOREMEN	REMARKS
into spindle, gears								
and bearings		R		AR	SP			
-check undue gear wear		S		AR				
-check oil condition		S		AR	VM			
-check tool post for								
tightness & tighten		S		AR	SP			
-check backlash on cross								
and compound slides;								
adjust if necessary		S		AR	SP			
-check tail stock								
traverse screw for proper								
locking		S		AR				
YEARLY - SERVICE								
-drain oil; refill with								
new oil		S		AR	SP			
-clean oil filter		S		AR				

Legend: AR Artisan S Stop machine R Running
TW Torque wrench VM Visual meter TM tacho-meter
G Gauge
SP Set of spanner

Figure iii-8: Proposed Maintenance Schedule

I. To set out a plan of work:

- to spread the maintenance workload evenly over the year
- to ensure that every facility or maintenance task is included
- to ensure that the required maintenance is carried out at the specific frequency
- to coordinate maintenance with production requirements

II. To present an overall picture of maintenance work; present and future commitments:

- to assist future planning, ordering of spare parts, future labour requirements, basis of budgetary control.

III. To act as a reminder of future maintenance events:

- to formulate weekly work plans
- to arrange for availability of machines
- to arrange or check availability of labour, spare parts, subcontractors, etc.

III.5.5 Job Card:

As mentioned earlier, the types of job cards used in most of Tanzania's industries lack some basic requirements. Ideally, the job card should be a statement recording the work done and the condition of the facility. It should provide a continuous flow of information to and from the tradesman doing the work.

NAME OF COMPANY: MAINTENANCE PROGRAMME

NO	NAME OF MACHINE	MONTHS		JAN				FEB				MARCH				APRIL				MAY					DECEMBER			
		WEEK STARTING																										
		WEEK NUMBER		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	49	50	51	52
		CODE NUMBER	MODE NUMBER																									
1	MILLING MACHINE	01-01-01		M		Q		M				M		Y		M		Q		M				M				
2	SURFACE GRINDER	02-02-01			M		Q		M				M		Y		M		Q		M					M		
3	CYL. GRINDER	02-03-01				M		Q		M				M		Y		M		Q		M					M	
4	CENTRE LATHE	01-04-01					M		Q		M				M		Y		M		Q		M					M
5	TURRET LATHE	01-05-01		M				M		Q		M				M		Y		M		Q		M				
6	NC TURNING M/C	01-06-01			M				M		Q		M				M		Y		M		Q					
7	NC MILLING M/C	01-07-01		Q		M				M		Q		M				M		Y		M		Q		M		
8	VERT. BORING M/C	01-08-01			Q		M				M		Q		M				M		Y		M			M		
9	HORNING MACHINE	01-09-01				Q		M				M		Q		M				M		Y		M	Q		M	
10	DRILLING M/C	01-10-01					Q		M				M		Q		M				M		Y			Q		M
11	SHAPING M/C	01-11-01						Q		M				M		Q		M				M		Y	M		Q	
12	SLOTTING M/C	01-13-01							Q		M				M		Q		M				M			M		

Lenged: M Monthly Maintenance Y Yearly Maintenance
Q Quarterly Maintenance

Figure iii-9: Proposed Maintenance Programme

Figure III-10 shows a conceived job card. The card is so designed that it supplies all the necessary information, further it has the following features:

a) it can be completed with a minimum of mental effort

b) the need for writing is kept to a minimum, and

c) it is self indicative of any work that has been omitted.

III.5.6 The History Record:

Many of Tanzania's industries neglect to keep records of machines. This is partly due to the non-availability of the cards. Thus, the urgent need to introduce these records to those shops which do not use cards, and to update the existing ones. This will ensure a foolproof system in the maintenance plan since plans do not always work out as anticipated. The record will show the validity of the technical assumptions made within the plan.

Each component in the maintenance plan should have an individual record which details the maintenance events during its operational life. The necessary contents of records are:

a) details of inspections, repairs and adjustments carried out

b) breakdowns and failures, their results, causes and corrective actions taken upon

c) work done on the component and whether repaired or replaced

d) conditions of wear, corrosion and measurements taken

e) time and cost to carry out the repair

Figure III-11 shows a proposed history card for Tanzanian industries. Although most of the information will be taken from job cards, some might be obtained through store requisitions, time and cost sheets.

III.5.7 Planned Lubrication:

One of the important solutions to Tanzania's industrial maintenance problems is a good planned lubrication system. Effective lubrication is a fundamental element of preventive maintenance. Tanzania's weather is mostly warm and humid for most periods of a year and the dust level is very high during dry seasons. These adverse conditions are detrimental to rotating/moving parts, including bearings. Heat and moisture accelerate corrosion while dusts cause corrosion and accelerate wear to rotating parts. It is believed that a good number of failures in machines originate from poor lubrication:

- incorrect grade of lubricant
- incorrect type of lubricant
- too much lubricant
- too little lubricant
- infrequent or absence of lubricant

NAME OF COMPANY:					J O B C A R D NO.			
DATE: ..... TIME:	CAUSE OF FAILURE:				NAME OF MACHINE ..... LOCATION & FAILURE DETECTOR			
MACHINE PART	DEFECT	TASK TACKLED	PROCEDURES AND TOOLS USED	MAN HRS	MAINTENANCE COST			
					MATL.	SPARES	OTHERS	TOTAL
RESTORATION APPROVED BY: ..... DATE:					TOTAL COST			
SPARES USED i) NEW ( ) ii) RECONDITIONED ( ) iii) 2ND HAND ( ) PLEASE (TICK)		SPARE PARTS TAKEN FROM THE STORE		SPARE PARTS TAKEN TO BE RECONDITIONED		REMARKS ON SCRAPS/MACHINE		
		SUPERVISOR'S SIGNATURE:		W/SHOP MANAGER'S SIGNATURE:				

Figure iii-10: Proposed Job Card for the Machine Shop

NAME OF COMPANY:

H I S T O R Y R E C O R D C A R D NO .....

NAME OF FACILITY:	LOCATION	DATE OF INSTALLATION .....
MANUFACTURER:	CODE NUMBER:	

S/N	DATE	JOB CARD NO.	SUMMARY OF: ITEM - DEFECT - CAUSE - CORRECTIVE ACTION -SPARES, MATERIALS USED	MAN HRS	MACHINE DOWN TIME	TOTAL MAINT. COSTS	REMARKS

Figure iii-11: Proposed History Record Card

Many industries have organized operators-maintenance worker teams. Operators are assigned some routine maintenance problems such as: lubrication, cleaning, making simple adjustments. But, since each machine may be operated by several operators at different times, it is difficult to assign the responsibility to them. A proposed system is to assign a specific person the responsibility of lubricating all the machines. This man should see that:

- every machine or item specified is correctly lubricated
- the correct type, grade and quality of lubricant is applied
- the correct lubricant is applied at regular periods
- the lubricant is recorded to indicate the effectiveness of the function

Figure III-12 shows a lubrication program. The initial step for the system is to carry out a comprehensive survey, listing all items to be lubricated. The survey should include details as follows:

- position to be lubricated
- lubrication - point reference number
- number of lubrication points
- type and grade of lubricant
- method of application
- frequency of lubricant change
- oil reservoir capacity.

NAME OF COMPANY:

L U B R I C A N T P R O G R A M M E

MACHINE REGISTER:

MACHINE: .....
NUMBER: .....

LOCATION: .....

S/N	ITEM	NO. OF POINTS	LUBR-CANT	APPL. METHOD	APPL. FREQ.	CHANGE FREQU.	REMARKS
1							
2							
3							
4							
5							
. . . .							

Figure iii-12: Machine Register Card

III.5.8 Control Cycle:

Figure III-13 shows a working cycle for maintenance activities. The cycle starts with planning maintenance activities. Not only preventive maintenance should be planned, but also activities associated with maintenance. Planning leads to carrying out activities. These activities may be routine or sometimes emergency repairs. In case of an emergency repair, it may be worth planning the job before starting. Records for operations and maintenance data should be set-up. The recording should include:

a) observations in connection with maintenance work, time used, spare parts, materials as well as production lost

b) what and when maintenance activities have been taken place

Record data has to be assessed and/or analyzed. This will help to influence the future planning. Thus, concludes the working cycle for maintenance activities.

III.6 Maintenance Staff Training:

The performance, skills and attitudes of the staff will directly influence the success or otherwise, of any maintenance plan. So, as much considerations should be given to the human element of the plan as is given to the more material elements. Manpower requirements, selection, utilization and training are primary areas which are a good practical basis upon which to initiate a plan.

The staff is the company's most valuable asset, and the selection should be done with utmost care. The first step in the selection procedure is to consider a vacancy and formulate a job description. Some of the factors that build-up job description are:

- job title
- job summary
- responsibility
- skill and ability
- technical and educational qualifications required
- training and conditions of employment.

Most of the workers in technical positions in Tanzanian industries are standard vii education leavers, and quite a few have acquired higher education. Thus, this suggests that more efforts are required in staff training.

III.6.1 Staff Training:

Mjema [60] has formulated the curriculum for artisans in Tanzanian industries. The fact that artisans form the vast majority of technical staff in industries, their development will improve the availability of skilled technical personnel in Tanzanian industries. The proposed training policy by the ministry of labour, agreed among the employer community, all ministries and organized labour in Tanzania, emphasizes on the training of artisans [40].

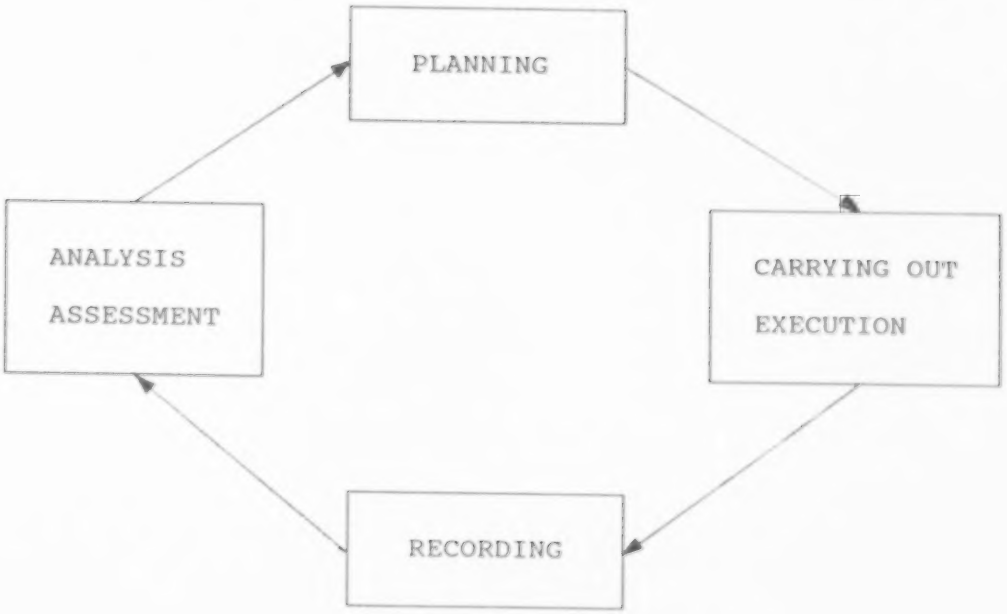


Figure iii-13: Working Cycle for Maintenance Activities

Figure III-14 shows the proposed trade training. Standard vii leavers, after 2 months probationary period with an employer, undergo a total of 12 months at the trade school and 3 years in-plant training before qualifying as an artisan. Great effort has been devoted in formulating the training for artisans. But, the problem still lies in the hands of employers. Some employers do not provide favourable opportunities for these young technical persons to develop themselves. However, courses of importance for maintenance staff as stipulated by Mjema are:

a) safety engineering
b) maintenance management
c) engineering drawing
d) english
e) mathematics
f) machining
g) welding
h) foundry/forging
i) auto-mechanics.

Some courses such as auto-mechanics and foundry need specializations. But an artisan who is intending to work with a manufacturing industry should be conversant with a wide scope of engineering applications. One useful tool for skills development is a willingness to put theories into practice by taking seriously the in-plant training.

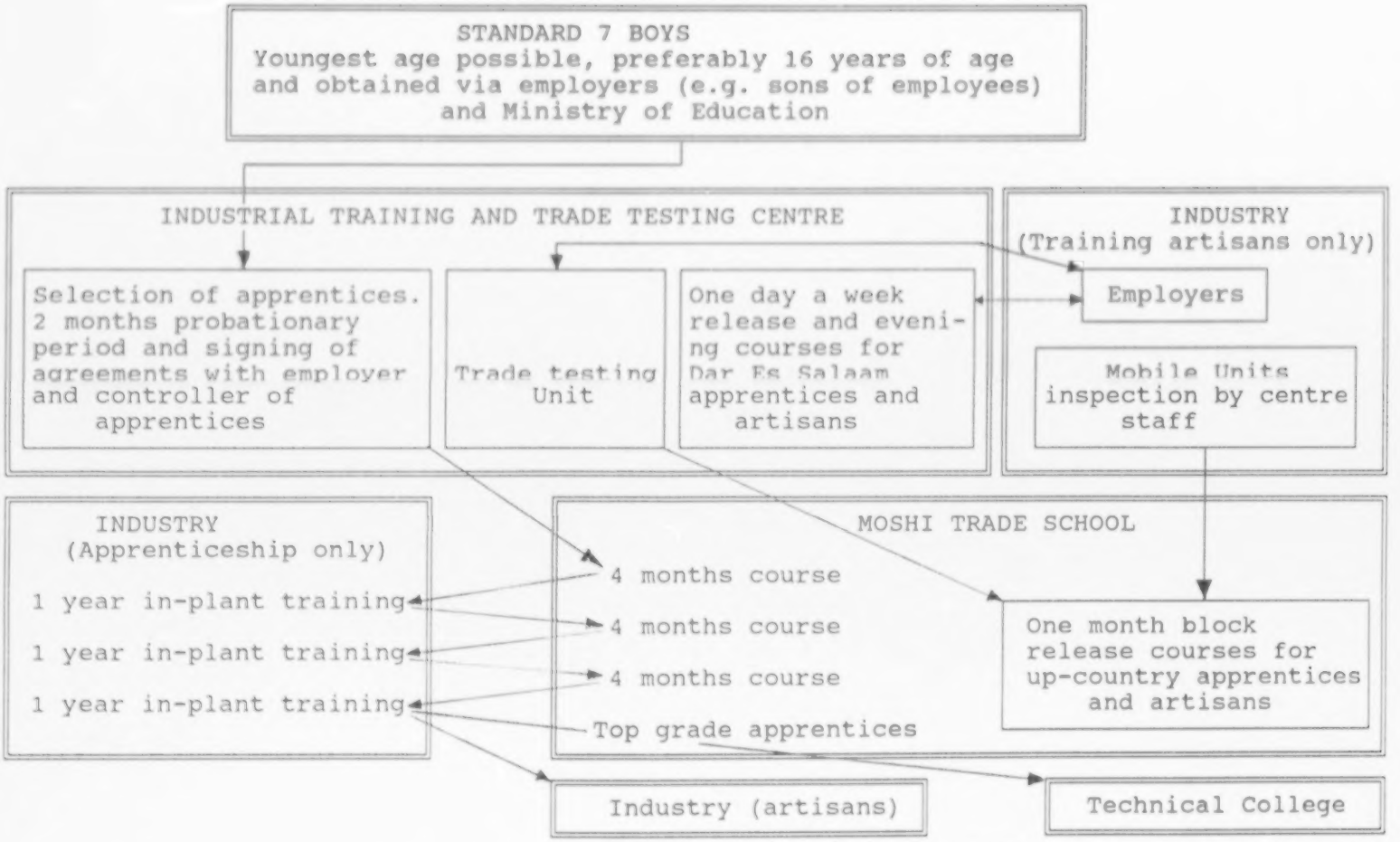

STANDARD 7 BOYS
Youngest age possible, preferably 16 years of age and obtained via employers (e.g. sons of employees) and Ministry of Education
INDUSTRIAL TRAINING AND TRADE TESTING CENTRE
Selection of apprentices. 2 months probationary period and signing of agreements with employer and controller of apprentices
Trade testing Unit
One day a week release and evening courses for Dar Es Salaam apprentices and artisans
INDUSTRY (Training artisans only)
Employers
Mobile Units inspection by centre staff
INDUSTRY (Apprenticeship only)
1 year in-plant training
1 year in-plant training
1 year in-plant training
MOSHI TRADE SCHOOL
4 months course
4 months course
4 months course
Top grade apprentices
One month block release courses for up-country apprentices and artisans
Industry (artisans)
Technical College

Figure iii-14: Proposed Trade Training

Source: Norman Lewis, Controller of Apprenticeship and Trade Testing, Dar-es-Salaam.